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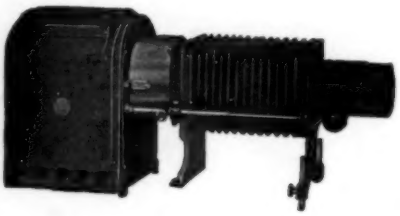

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXI, NO. 5 MAY, 1921 WHOLE NO. 178

TEACHING FORMULAE IN THE JUNIOR HIGH SCHOOL.

BY JOS. A. NYBERG,

Hyde Park High School, Chicago.

Ability to use a formula is now regarded as one of the most important bits of knowledge to be acquired by every pupil from his high school mathematics. Since examples of the formulae, which can best be used in the ninth grade are found in every text book, the following paragraphs consider some other aspects of the subject—chiefly how the subject may be taught.

The mathematics of the ninth grade differs from the pupil's previous work in two respects, (1) the use of negative numbers as well as positive, and (2) the use of letters to stand for numbers. Since the latter notion is usually introduced first and as many formulae do not involve negative numbers, it is possible to introduce formulae the first week of the year. If we say sugar costs ten cents a pound so that the cost, c, of n pounds is $10n$, then $c = 10n$. This may be a simple illustration of a formula; but a poorer illustration can hardly be found. The relation is so trivial that the pupil may well become indignant and disgusted at the teacher for making such a mountain out of a molehill, and the pupil can not be blamed for losing interest at such an obvious result. The problem must command the pupil's respect. A more interesting and also very simple problem is that of dividing a number into two parts having a given ratio. This problem can be handled during the first week, and I present it here in some detail just as it is presented in the class:

"A carpenter wishes to divide a board 16 ft. long into two parts such that one part will be twice as long as the other. If the board were 15 ft. long this would be an easy matter as he can readily guess that one part should be 10 ft. long and the other 5 ft. But since the board is 16 ft. long he marks off three

equal divisions on his board. How long is each division, all three divisions being equal? He then saws off the board at one of the division marks. How long is each piece? If the carpenter wants one piece to be three times as long as the other piece, into how many divisions should he mark the board? At which one of the marks does he saw the board? If the board were 18 ft. long how long is each division? (And parenthetically I ask some inattentive youngster just how many pencil marks the carpenter has made on his board. This is to help the pupil visualize the performance.) How long are the two pieces after sawing? If he wants the ratio of the two pieces to be 4 to 3, in how many equal divisions does he mark the board? Where does he saw it? How long are the pieces?"

Then after working a few arithmetic exercises, I ask the class to write in complete sentences the directions for dividing a board into two pieces having a given ratio, each pupil choosing his own length and a definite ratio. The directions are read aloud and criticized. Next I produce from the cupboard a board about two or three feet long and a saw, saying, "I am not going to tell you how long this board is, but I wish to saw it in two pieces having a certain ratio, and I do not wish to tell you the two numbers in the ratio. Can anyone give me the directions for doing the work?" Some one volunteers, and I ask the rest of the class to write down what he tells me, that there may be no disagreements afterward. The pupil usually says: Add the two numbers in the ratio, and divide the length of the board by that, etc. When the sawing is completed we discuss what the pupil said and conclude that he should have said: (This I write on the blackboard.)

Call the length of the given board l, and the given ratio a to b. Find $(a+b)$. Find $l/(a+b)$. Find $a \times l/(a+b)$ and $b \times l/(a+b)$. These are the lengths of the desired pieces.

On the previous day when evaluating some algebraic quantities we had learned that $a \times b/c = ab/c$ and so we can add that the lengths of the two pieces are $al/(a+b)$ and $bl/(a+b)$. Next I point out this significant fact: when working the problem by arithmetic we divided l by $(a+b)$ first, and then multiplied the result by a; now we see that if we were working a hundred such problems in a speed test, it would be advisable to multiply a by l first and then divide this result by $(a+b)$; that is, *the letters have shown us a quicker way of getting the results.* Hardly by arithmetic would it have occurred to us to multiply the

length of the board by one of the numbers in the ratio. Such a problem as this commands the admiration of the pupils because the results seem both useful and unusual.

About a week later we will be solving simple equations such as x = John's age, $3x$ = Henry's age, etc., and so I repeat some problems like the one above. x = length of one piece of the board, $3x$ = length of other piece, $4x = 18$, etc. And as extra work for bright people in the class I assign the problem of showing that $x = al/(a+b)$ can be found from the equations in the same way that we discovered it experimentally. Also in every geometry class, when a line is to be divided into parts having the same ratio as two given lines, all of this work is repeated with emphasis put on the algebraic work as well as on the geometric construction. The reader will notice the correlation of the subjects, arithmetic, algebra, geometry; and to the writer it seems that this is the kind of correlation most worthy of consideration.

The next use of any formulae comes a few weeks later when exponents have been introduced, and we are to use the relations about areas and circumferences of circles. At this point I have what may seem a rather undignified and untruthful way of introducing the letter π. I tell the class that one day a Greek discovered that whenever he divided the circumference of a circle by its diameter he always got the same number for a quotient. The number became so famous that a special letter of the alphabet was assigned to it, the Greek letter π. The number became famous because it had so many uses; for example, if the square of the radius was multiplied by this miraculous number, the result would be the area. We write this as $A = \pi r^2$. And if the radius is cubed and then multiplied by $4\pi/3$ the result is the volume of the sphere, or $V = 4\pi r^3/3$. At this point we actually introduce the word *formula* meaning *the most concise way of stating how something can be computed.* Our first problems deal with A and V. The relation $C = 2\pi r$ is used last and least because we happen to be studying exponents and because this relation seems obvious considering how π was introduced. By that I mean that the pupil can find the circumference without consciously thinking of any formula.[1] In using any formula whether dealing with a circle or the horsepower of a gasoline engine it is advisable to devote some time

[1]To make the number π really meaningful to the pupil I have each one bring to class a tin can, and determine the value of π by finding the circumference with the aid of a tape measure, and the diameter by measuring the greatest width of the can.

to encouraging neat and systematic work. Thus, in finding the volume of a circular cylinder whose height is 15 and the radius of whose base is 12, the following presentation may be used:

Given: $r = 12$, $h = 15$. Find V.
Use: $V = \pi r^2 h$, $\pi = 22/7$

$V = 22/7 \cdot 144 \cdot 15 = 6788.6$

$$
\begin{array}{r}
144 \\
22 \\
\hline
288 \\
288 \\
\hline
31680 \\
15840 \\
\hline
7\,\overline{)\,47520} \\
\hline
6788.6
\end{array}
$$

Mental arithmetic, such as writing 144 instead of 12^2 should be encouraged also. The arithmetical work should never be done on some other paper and then thrown away but should be shown alongside the other work. The use of the word *given* and *find* has many advantages and will make the later work in geometry seem less artificial. As some problems will use $\pi = 22/7$, others 3.14, or 3.141 or 3.1416 (according to the character and number of decimals of the given numbers) the pupil should be required to state his choice.

Thereafter formulae may be used at various times as they arise. Such relations as $p = 4a$ for the perimeter of a square, or $A = a^2$ for its area, or $p = a+b+c$ for a triangle, I hesitate to call formulae for the reason that they are too obvious and too useless. Very seldom does anyone use them *as formulae*. $p = a+b+c$ is, to my mind, a definition written in algebraic language. To avoid cheapening the word, it ought to be reserved for more important relations. The formula for converting Fahrenheit temperature into centigrade, and vice versa, is very useful and desirable as an illustration for negative numbers except for the difficulties involved in deriving the formula. There are other problems which not only use formulae but are interesting in other ways; for example, in every attempt to correlate mathematics it seems popular to use in algebra classes the fact that the sum of the angles in a triangle is 180°, and the sum of the angles around a point 360°. After working a few problems involving these two facts I like to ask the class: "Isn't the sum of something or other 540° or 720°? Why all this undue emphasis on 180° and 360° always?" We find the sum of the angles of a square or a rectangle is 360°. Is it so for all four-sided figures? What about five-sided figures? By

dividing a polygon into triangles we find the sums of the interior angles and prepare a table showing how the sum of the angles compares with the number of sides. We write

n, number of sides,	3	4	5	6	7	8
a, sum of angles,	180°	360°	540°	720°	900°	

Without drawing a figure with 369 sides can you predict what the sum of the angles would be? How do you compute a knowing n? We find $a = 180(n-2)$. If the pupils do not easily see the relation from the above table I suggest using a right angle as the unit of measure so that the numbers for a are 2, 4, 6, 8, 10, . . . This formula differs from previous ones in that it has no meaning if n is a fraction or is less than 3. If the class then shows sufficient enthusiasm we can consider the problem of the number of diagonals, d, in an n sided figure. The sequence of numbers for d is 0, 2, 5, 9, 14, 20, . . . By calling attention to the successive differences, 2, 3, 4, 5, . . . of any two values of d, the pupils easily see how this sequence is built but some help is needed before they discover that $d = n(n-3)/2$. These two problems also furnish links in the gap between algebra and geometry.

The *Preliminary Report by the National Committee on Mathematical Requirements* [2] mentions

"The formula—its construction, meaning, and use—

(a) As a concise language.

(b) As a shorthand rule for computation.

(c) As a general solution.

(d) As an expression of the dependence of one variable on other variables."

The items (a), (b), and (c) are well illustrated by the problem of dividing a line in a certain ratio. Every new type of equation or quantity affords opportunity for introducing new formulae and further practice on items (a) and (b). But if I understand item (c) correctly, I doubt whether much time should be spent on it, especially not in the ninth grade. I believe that "One of the chief differences between algebra and arithmetic is that in arithmetic each problem is solved for special numbers, thus obtaining a result which gives no clew to the result in a problem entirely similar where different numbers are used. In algebra letters are used instead of Arabic numerals, thus obtaining a result that constitutes a formula for the solution of all problems of the class of which the one solved is a general

[2] Secondary School Circular, No. 6, Bureau of Education, Washington, D. C.

type. . . . . The solution of the general or literal problem resulting in a formula applicable to all problems of a large class is essentially the work of algebra. The solution of a problem stated in terms of Arabic numerals is essentially the work of arithmetic."[3] Hence a careful treatment of the item (c) means an extended study of so-called literal problems. $c = 10n$ is not a general solution; $c = an$ is. The age problems would have to be extended until the pupil could solve, "Find the ages of A and B if A is now a times as old as B, and h years hence will be b times as old." And even if we do not solve "A's rate exceeds a times B's rate by b miles per hour; if they walk toward each other from points c miles apart and A starts e hours before B, how soon will they meet?" then item (c) would at least imply that we solve such problems as "Find two numbers whose sum is s and whose difference is d" or "If A can do a job in a days and B do it in b days, how many days are required if they work together?" Under the recently proposed reforms in high school mathematics there would be little time for such general problems. But there are two general formulae which ought to be considered, the one for a quadratic, and the other for a pair of linear simultaneous equations. To develop these intelligently and without thrusting them boldly at the pupil accompanied by an illustration of their use is a difficult matter. The following method of handling them may be of interest:

After the class has solved simultaneous equations for some days I assign $-5x+9y = 17$, $7x-6y = -4$. When the pupil has found $x = 2$, $y = 3$, I ask, "If the first equation had contained $10x$ instead of $-5x$ would not the final value of x have been different? Does not the pair of answers depend on the numbers -5, 9, 17, . . in the given equations? Then if I am told the numbers in the equations, ought I not to be able to find a rule with which to predict the answers? How might the rule read? It might say: multiply this number (pointing to one of the coefficients) by this number perhaps (pointing to another coefficient) and get 2 for the x." It is an unusual class in which some one does not say that x can be found by adding the 7 in the second equation to the -5 in the first, and y can

[3]From a pamphlet, "The Teaching of Algebra, with special reference to Slaught and Lennes High School Algebra." It is interesting to note that this text published in 1908 contains many of the ideas whose value we are beginning to appreciate only today. Thus the first 171 pages deal entirely with the solving of equations, even linear simultaneous equations; then products of binomials and factoring are treated with immediate applications to equations. Division of polynomials by polynomials does not arise till page 218 and is then a preliminary to square roots, radicals, and quadratic equations. The treatment of fractions comes last and serves as a general review of equations.

be found by adding the -6 in the second equation to the 9 in the first. I have of course made my equation so that this will attract his eye, and have deliberately pointed to these numbers while talking. His method is wrong for surely the 17 and -4 must be taken into consideration. So we begin analyzing our solution. The $y = 3$ was obtained by dividing a 99 by a 33. Where did the 99 come from? From adding the 119 and the -20. Where did the 119 and -20 come from? From multiplying the 17 by 7, and from multiplying the -5 by -4 and changing the sign; and these are numbers which appear in the given equations.

Returning now to the number 33, where did *it* come from? Thus we trace our solution backward until we see where and how every coefficient in the given equations has contributed to the final denouement. Having thus traced the value for y I find the pupils get actually excited about tracing the mystery for x. No youngster ever took a clock apart to see what makes it tick any more enthusiastically than he dissects the value of x. Moreover, some of the pupils solved the equations by the substitution method and some by the "multiplication and addition" method.[4] The fact that the same numbers 99, 119, -20, etc., appear in both solutions and that the explanation of a pupil who used one method applies also to the work of a pupil who used the other method seems actually miraculous to the pupils and always causes a great deal of surprise. We teachers have become so blase to the wonders of mathematics that we forget many things which can be made to appear wonderful in the pupil's eyes.

In order to be able to write a rule in concise language we decide to call the coefficients a, b, c, exactly as we did in the first problem about the carpenter and the board. Also we can derive the general solution directly from the equations $ax+by = c, dx+ey = f$, and the pupils will now understand what is being done.

This same method of explanation can be used in deriving the formula for the solution of $ax^2+bx+c = 0$. But as quadratics are studied near the end of the year when the pupils have acquired more skill in handling all sorts of literal expressions, the following shorter method can be used: When the pupil has

[4] This method is usually called the "addition or subtraction" method. I prefer the name "multiplication and addition" because the pupil actually does multiply the two equations by the two numbers and then add. There is never any necessity for subtraction since negative multipliers may as well be used as positive ones.

solved $ax^2+bx+c=0$ and found $x=[-b+\sqrt{(b^2-4ac)}]/2a$ I do not call this a formula but develop again the concept by asking: "If now you were asked to solve $ax^2+bx+d=0$ would it be correct merely to replace c by d in the solution already found? Then to solve $ax^2+ex+d=0$ could I replace b by e in my last solution? To solve $3x^2+ex+d=0$ could I replace a by 3? How can I use my first solution to solve $3x^2+2x+d=0$? The pupil will then begin to see that one solution containing a, b, c, is a composite of the solutions of all quadratics. Here I would like to repeat what was said in a previous paragraph: that, whenever possible, some of the arithmetic should be performed mentally. The mere sight of an expression $[-(-7)\pm\sqrt{(-7)^2-4(3)(2)}]/2.3$ as a solution of $3x^2-7x+2=0$ is enough to discourage any pupil, whereas if he is taught to write at once $[7\pm\sqrt{(49-24)}]/6$ the work will be easier.

The object of this paper was to explain how the notion of what a formula is may be taught. There are teachers who fear that the use of formulae eliminates thinking and becomes a matter of formal manipulation, which the pupil may learn to do but never learn to understand. Their argument seems to hinge on the assumptions (1) that the pupils in physics or other applied fields cannot use the mathematics which they have studied, and (2) that our grandfathers who solved by arithmetic such problems as "How much does a fish weigh if the body of the fish weighs 30 pounds, the head twice as much as the tail, and the body and head together weigh three times as much as the head?" received a training in analytical and independent thinking that our present system of education does not give the pupil to-day.

All teachers are familiar with the answer to the first objection; namely, that a pupil may understand a process or method or idea very well in one set of surroundings but show an amazing unfamiliarity with them in some other surroundings. Thus in algebra the pupil may learn to subtract polynomials and score 100 on any examination on subtraction but still make various errors when doing the subtracting necessary in long division. He may learn to write $(x-4)^2=x^2-8x+16$ but when he solves $3x+(x-4)^2=5+(x+6)^2$ he will write x^2-16 for $(x-4)^2$. . Teachers in high school similarly complain that arithmetic is not taught thoroughly in the grades, forgetting that the pupil who says $1/2+1/3=5/6$ in the grades may use $2/5$ as the sum in any unfamiliar situation. A pupil may learn his trigonometry

quite well but not be able to resolve the forces acting on an inclined plane into its various components. The $\cos\theta$ which he uses in such a problem is not the $\cos\theta$ with which he became acquainted in the trigonometry class because it has different surroundings. The college student may learn all about E, i, and R in a physics class but not understand them when he meets them in a differential equation. Hence good teaching has always required that every fact should be established by a multiplicity of associations. And an old idea used in different surroundings must be carefully developed anew. Physics and chemistry teachers must either avoid formulae in their classes or else take the time to convince the pupil that the formulae in their texts are really the same ones that appeared in the algebras.

The second objection refers not only to the teaching of formulae but to all teaching of mathematics, and is more difficult to refute in a short space. The past has always seemed rosier than the present. Every adult thinks that the winters were colder when he was young; that the children in his day had more fun than the children of to-day, and had to work a great deal harder, and took life more seriously. And will not the coming generation say exactly the same things fifty years hence? And who can answer such impressions? But I think it is safe to say that almost any youngster of to-day can think more clearly and analytically than his grandfather did fifty years ago. Just to try them I copied on the blackboard the data given on page 717 of SCHOOL SCIENCE AND MATHEMATICS, November, 1920, and asked what the relation might be between E (the elongation) and P (the pull). Some of the answers were "E is some numbers times P," "E is about 6 times P," "E = 6P approximately," "Draw the graph for E and P to see whether it's a line or curve," "It looks as if the graph would be a line," "Put E = kP and see if you can find k." Good answers, I think; but I will admit the class has had frequent exercises in trying to find the relation between x and y from statistical data as illustrated in the previous problem about the sum of the angles in a polygon.

THE MATHEMATICAL ASSOCIATION OF AMERICA.

By G. A. Miller,

University of Illinois, Urbana, Ill.

As many teachers of secondary mathematics naturally look forward to college teaching we give here a brief account of a comparatively recent organization which is intended primarily to promote the interests of college teachers. It may be desirable to consider also briefly the rapidly growing general tendency to organize teachers of mathematics as has recently been illustrated by the new mathematical organization called National Council of Teachers of Mathematics.

When it is recalled that only half a century ago there were very few mathematical organizations, the oldest of the strong mathematical societies having been organized in 1865 under the name London Mathematical Society, and that now mathematics teachers of various grades are invited to join a number of such organizations, one naturally pauses to reflect on the reasons for this change. Perhaps one may be at first inclined to inquire whether the world has gone crazy on organization and whether it is not best to avoid as far as possible this new whirlpool which seems to be absorbing much energy that is needed for study and better service to the students.

Nevertheless it is of considerable interest to try to discover reasons for this change since these reasons may throw light on what our attitude should be in regard to it. One obvious reason is that the improvements in the facilities for travel naturally lead to more state, national, and international meetings. National mathematical societies could not have been a success before the development of a fairly extensive railroad system. The natural tendency to organize for mutual improvement had, therefore, to be held in abeyance by mathematics teachers until the facilities for travel were sufficiently advanced to make it feasible for them to get together in sufficient numbers and at sufficiently frequent intervals to make such organizations profitable.

A second potent reason is that facilities for publication have rapidly improved during the last century and the cost of publication has in general decreased as compared with the financial incomes of the teachers. Hence it has become possible for teachers to secure more literature relating to their work than in former years. Nearly all the larger mathematical organizations render greater service to their members by means of

periodic publications than by means of their meetings for the discussion of questions of common interest.

The indirect forces just mentioned which have contributed to the rapid growth of teachers' organizations during the last half century were due to the partial removal of obstructions, which have always hindered teachers from doing what they would have liked to do. Our predecessors would, doubtless, have enjoyed the advantages of meeting their colleagues and reading about their work just as much as we do but the obstructions in the way of their realization were then too serious to make it feasible for them to enjoy these advantages. Even when many of these obstructions were removed the force of habit seemed to have stood in the way of making the best use of the new situation.

In the light of these facts, it seems reasonable to assume that organizations have not only come to stay but are likely to become still more potent factors in the future. The live teacher has to make use of all available opportunities if he desires to secure or to maintain a position in the front rank and to live in accord with Bacon's well-known dictum: "I hold every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and an ornament thereunto."

The Mathematical Association of America is only five years old but it has attained a membership of about 1,200. One is naturally much interested in such a vigorous youth but the readers of SCHOOL SCIENCE AND MATHEMATICS should be especially interested in this association in view of the fact that it emphasizes the *teaching* of mathematics in our higher institutions. The fact that so many of our university professors have joined this association bespeaks a deeper interest on their part in the question of teaching and clear presentation of known facts than is usually accredited to them.

It is interesting to note also that some of the leading European mathematicians, including Emile Borel of Paris and Federigo Enriques of Bologna, have become members of this association and have thereby exhibited their deep interest in a mathematical organization, which does not have for its chief aim mathematical research. The official organ of this association, called *The American Mathematical Monthly*, presents varied and important advantages relating both to the improvement of mathematical

knowledge and also to suggestions as to the best methods for presenting collegiate subjects in the class-room.

Some of the readers of SCHOOL SCIENCE AND MATHEMATICS who are familiar with the *American Mathematical Society* and its two valuable publications, known as the *Bulletin* and the *Transactions*, may perhaps wonder why the American university professors of mathematics felt the need of a new organization and an additional journal. This wonder may increase if it is noted that all of the meetings of the new organization have thus far been held almost jointly with those of this *Society*. It might at first appear from this fact that this new organization was a kind of parasite of the Society. On the contrary, it aims to be an aid to the development of this parent organization by providing better facilities for the growth of the younger mathematicians.

Doubtless many have joined the Mathematical Association of America mainly because they desired to help in this way to improve the advantages of those who found the gap between the regular research journals and those devoted to the interests of teachers in the secondary schools too wide. This is especially true of those whose main interests are in mathematical research but who realize that there should be a broad and harmonious development of the entire field of mathematics in order that mathematical research may be directed into the most useful channels. Just as there is danger in too narrow specialization, so there is danger in losing contact with those whose mathematical interests are not identical with our own.

A fundamental idea underlying all organizations is that in union there is strength. The realization of this strength tends to inspire the members of the organizations with a deeper interest in their work and with a greater desire to excel. While there is obviously a limit to the number of professional organizations to which one can profitably belong, it is likely that most young mathematicians join too few rather than too many of them. The assistance which one can thus render with a comparatively small expenditure of time and money will in many cases reflect favorably on those who render it in the most altruistic spirit.

The fact that American college teachers of mathematics have found it desirable to promote their common interests as teachers and investigators by means of two distinct organizations, which cooperate harmoniously as far as their common interests permit

and support each other's efforts to promote especial interests, may appeal to many non-mathematicians as worthy of especial note. These two organizations are evidence of the wide range of mathematical activities which confront the college teacher of mathematics, and of the fact that those who excel along one line may be scarcely understood by those who excel along another line. In view of the fact that these organizations have such a large common membership, it seems unlikely that they will ever become antagonistic.

In its form of organization the Mathematical Association of America aims to be quite democratic. Not only is there a primary and a final balloting but twice as many persons are nominated for a particular office as are to be elected. Hence the members who exercise their privilege of voting have opportunities to express their preferences in an effective manner, as regards certain men available for officers, who, in turn, elect several of the most important service officers. This really democratic form of government differs widely from that of the American Mathematical Society where the method of election is such that the ordinary members are likely to participate only formally.

As these two organizations have so many members in common they seem to present a good opportunity to test whether American scientific bodies prefer a democratic or an aristocratic form of government. Both of these forms of government have obvious advantages in the scientific life as well as in the political life of a nation. In so far as the election to an office in a scientific body is an expression of recognition for important scientific work it is clear that effective and serious participation on the part of all those competent to judge is desirable in view of its effect on the participants. Possibly such recognition should occasionally be given to men who are not necessarily members of the particular organizations concerned. The importance of successful scientific efforts is such as to warrant a deeper general public interest, especially since such public interest is likely to be a powerful incentive to others to try to make important advances.

As regards election to membership the Mathematical Association of America is also quite democratic, since it demands only *interest* in collegiate mathematics on the part of those who seek membership. In fact, it has elected a large number of institutions to membership. These are naturally of a more

permanent type than the individual memberships, and the current literature received by institutions is apt to be made more permanently available than the literature received by individuals. Hence this association seems to have acted wisely in securing a permanent position in the mathematical work of so many of our educational institutions, which is a noteworthy step in the history of American mathematical development.

The Mathematical Association of America aims to serve the public through various committees, which bring it also in close contact with teachers of secondary mathematics. Among these is the National Committee on Mathematical Requirements, which has recently been enabled to do most efficient work as a result of generous financial support received from the General Educational Board of New York City. The association maintains a Bureau of Information, which is ready to render free and prompt services, especially to those of its members who may not have access to good libraries. Its Committee on a Mathematical Dictionary hopes to provide a useful reference work whose need has been long felt by many mathematicians of this and of other lands. In fact, this association aims to serve in many different ways and to fill a real want in the mathematical life of our country.

DIOPHANTINE ANALYSIS APPLIED TO THE CONSTRUCTIBILITY OF REGULAR POLYGONS.

By M. O. Tripp,

University of Maine, Orono, Me.

The question of the possibility of constructing regular polygons is one of especial charm, not only to the teacher of elementary geometry, but also to the advanced student in the theory of equations and the theory of numbers. Gauss, with all his breadth and depth of mathematical knowledge, considered his researches along this line among the most important of all his mathematical work. As a corroboration of this statement, I refer to Weber and Wellstein's *Encyclopdiäe der Elementar Mathematik*, Vol. I, p. 353, foot-note, which runs as follows: "As it is reported of Archimedes, that he wished his tomb to display the sphere with the cylinder, so Gauss expressed the desire to perpetuate on his tomb the figure of the polygon of seventeen sides. This incident shows what value Gauss himself placed upon this discovery. On the sepulchre this wish has not been complied with; however, upon the monument which has been erected

to Gauss in Brunswick, the statue stands upon a polygon of seventeen sides, although it is scarcely visible to the observer."

In the elementary texts on geometry it is shown how to construct regular polygons of 3, 4, 5, 6, and 10 sides. Gauss has shown how to construct regular polygons of 17,257 and 65,537 sides. It is of considerable interest to investigate how these results may be used to construct other regular polygons. In particular, the case in which the number of sides is the product of two numbers relatively prime to each other deserves especial attention.

The construction of the regular polygon of fifteen sides is carried out by laying off an arc equal to one-sixth of the circumference, and from one extremity of this arc another arc, partly covering the first, and equal to one-tenth of the circumference; the chord of the arc representing the difference of these two arcs is the side of the required polygon. By Diophantine analysis the above problem may be carried out by considering the indeterminate equation

$$1/15 = x/3+y/5,$$

or

$$1 = 5x+3y,$$

and solving for integral values of x and y. Clearly one such pair of values is $x = 2$, $y = -3$. This means that if we take one-third of the circumference and double it, thus getting 240°; and then one-fifth and multiply by 3, thus getting 216°, the difference is 24°, an arc corresponding to a side of the pentedecagon. It should be noted that the unit involved in the first of the above equations is the circumference.

Again, if we wish to construct a regular polygon of 102 sides, we must solve in integers

$$1/102 = x/6+y/17,$$

or

$$1 = 17x+6y.$$

Here one solution is $y = 3$, $x = -1$. The corresponding geometrical operation consists in multiplying the arc corresponding to a side of the 17—gon by 3, and then subtracting the arc corresponding to a side of the hexagon.

It is interesting for us to inquire at this point, whether indeterminate equations of the kind we have been considering are always solvable in integers; for if they are always thus solvable, then it is always possible to construct a regular polygon whose number of sides is the product of two numbers relatively prime to one another, provided these relatively prime numbers represent the number of sides of constructible regular polygons. The answer to our inquiry is in the affirmative, and expressed in the

following theorem: *If a is prime to b, two integers m and n can always be found such that*

$$ma+nb = 1.$$

This theorem is proven in standard treatises on the theory of equations, and in some texts on advanced algebra. For the history of various methods of solving indeterminate equations of this type the reader is referred to Dickson's *History of the Theory of Numbers*, Vol. II, p. 64.

The equation

$$1/4369 = x/257+y/17$$

leads to the construction of a regular polygon of 4,369 sides from regular polygons of 17 and 257 sides. In this case the solution is not readily seen by inspection. In such an event we proceed with a and b as in the process of finding the greatest common divisor by the Euclidean method. Thus

$$257 = 15(17)+2$$
$$17 = 8(2)+1$$

Hence we have

$$1 = 17-8(2) = 17-8[257-(15)(17)]$$
$$= 121(17)-8(257)$$

Hence one solution of our given equation is

$$x = 121, y = -8.$$

Hence if we take the arc corresponding to the side of a regular polygon of 257 sides and multiply it by 121, and then subtract 8 times the arc corresponding to a regular polygon of 17 sides, we get an arc corresponding to a side of a regular polygon of 4,369 sides.

POTASH FROM NEBRASKA LAKES.

Until 1915 the United States produced no potash salts from native material except wood ashes, but in that year potash was produced from kelp, dusts from cement kilns, and alunite, and from the alkali lakes of western Nebraska. The possibility of developing the reserves of raw material from the first three of these sources has been studied and reported on by the United States Bureau of Soils, of the Department of Agriculture, and the United States Geological Survey, of the Department of the Interior, but no Government report has heretofore been issued on the potash resources of Nebraska. In 1918 W. B. Hicks, of the Geological Survey, spent three months in the alkali lake region of Nebraska, visiting the plants and the productive lakes; collecting samples of brine, water, sand, and mud for analysis; and making a general study of the region. The information he obtained has been studied and careful estimates have been made of the quantity of potash soils in these lakes. These estimates and notes concerning the probable source of the potash salts are contained in Bulletin 715-I, which may be had upon application to the Director of the United States Geological Survey at Washington, D. C.

A PROJECT IN GIRLS' PHYSICS.

By W. A. Tippie,

West Technical High School, Cleveland, Ohio.

As the class in girls' physics was looking forward to the completion of a study on home lighting the topic of discussion among its members was "What is the next field of endeavor likely to be?" Probably as a result of this unofficial discussion, one of the bolder spirits of the class suggested to the instructor that the class would be interested in a study of photography, closing with the argument that a number of the girls possessed kodaks On further inquiry by the instructor the following additional reasons for such a procedure were adduced. First, it was in line with other projects on our program. Second, there was a reference to the subject in the text which would justify its being proper for study. Last, but not least, members of the class had observed that off the laboratory was a dark room used occasionally by technical teachers and special students.

But the instructor did not have this project on his program. He had scheduled a few weeks' studies in electricity, finishing the semester with that popular (?) subject in girls' classes—mechanics. Therefore, while the instructor was impressed with the line of argument he instinctively replied that something might be done along that line as "individual projects." That evening, however, while taking a walk and gazing at the stars, a new light came to him. It had dawned upon him how the suggestion made in class might be used as a class project. At the next meeting of the class, to their surprise and joy, he announced that if within the next week each member of the class would make for herself a pinhole camera the desired subject would be studied. Although no one in the class had ever heard of such a device, ready and universal assent was given to the proposal.

Of course, the first problem was how to make the camera; so a search for the necessary information was planned. Some would consult photographers and other private sources, some would go to the school library and others to their nearest branch library. The instructor considered the whole subject of sufficient importance that he betook himself after school to the technical department of the main library. Many and varied were the reports next morning. Some said they had been laughed at by people "who ought to know." Another reported that a pinhole camera was a "device for scientific discussion but never used

for practical purposes." But one girl, who had scanned the table of contents of every bound volume of Popular Mechanics published since 1902, saved the day and restored confidence in the feasibility of the project. She brought a volume containing an article telling how such a camera might be adapted from a cigar box; also cuts of pictures that had been made with pinhole cameras.

We were now getting started with our project. A report was made on a method of constructing the camera. The instructor remembered that stored away in the dark room were several boxes of "8x10" dry plates just "spoiling" to be used. So it was planned that a sufficient number of them would be quartered and the cameras should be constructed for 4x5 plates. During the next few days while material (and sometimes help) was being obtained for the construction of each individual camera such topics as follow were discussed in the class and notes taken:

Why the box must be light-tight when loaded and the inner lining black.
Size of pinhole and time of exposure.
Effect of different focal lengths.
How to determine the distance to place camera from object to produce desired size of image on plate.

A committee from the class prepared the developing solution recommended by the makers of the plates; also a fixing-bath. The instructor gave about this time a test-tube demonstration lecture on the chemistry of photography.

At last came the laboratory day on which the cameras were to be used. There was a tenseness about the situation, not unlike that which existed when Robert Fulton was about to start his steam boat up the Hudson. One member of the class, who had some experience in photography, was assigned as an assistant in the dark room to see that cameras were properly loaded and to oversee the developing of the plates, the students being admitted in small groups for either purpose. The laboratory period came after classes for the day were over and for two hours or more there was a regular bombardment of the school building and such other still objects in the neighborhood as made suitable studies. At first, there was considerable indignation over loiterers between the cameras and the subjects being photographed, the time of exposures being very long—from fifteen to thirty minutes. However, to the suprise of the operators, when they developed their plates they found not a trace of students leaving the building, passing vehicles, etc. The dark room now became the seat of considerable activity. More workers

began to frequent it than had all told in its previous history. Pinhole cameras were loaded for exposures to be made at home, and even trick pictures were attempted. Owners of kodaks for the first time began to develop their own films instead of taking them to nearest drugstore.

The next regular laboratory period was given over to making prints from the best negatives obtained For this work the laboratory was converted into a dark room. Ruby lamps, which the class made, developing trays, etc., were arranged in groups about the laboratory. The exposures were made in an adjoining room. By this time the test-tube lesson on photography was fully appreciated as the different processes were discussed. In the meantime reports were made in the class on the following subjects:

Lens Camera vs. Pinhole Camera.
History of Photography.
Motion Picture Photography.
Scientific Uses of Photography.
How to Choose a Camera.
Color Photography.

A temporary collection of literature on photography was made for general class reading and discussion. Also one class period was given over to the photographer member of the class for a complete demonstration of the enlarging process. On the whole, it was agreed by the instructor and class that the two weeks given to photography were well-spent even from a practical viewpoint; and at the same time as many as usual worth-while facts of science were learned.

FLORIDA SETS NEW NATIONAL RECORDS.

The University of Florida has made an unprecedented national record by increasing the number of persons receiving instruction seven times during the past twelve months. This has been made possible by offering extension courses through a new General Extension Division.

By enrolling 5,804 students during the first twelve months in its history, the Florida General Extension Division also broke by a wide margin all records for the first year held by the thirty-eight others states doing similar work. Students were enrolled in correspondence courses from every county in the state and from nineteen other states and foreign countries. This is considered a noteworthy achievement, since Florida has only about 560,000 white residents scattered over 58,666 square miles and no general extension work had previously been carried on.

Mr. B. C. Riley, who first organized the work in the field for the Extension Division of the University of Indiana, after it was established in 1914, and left Indiana to enter agricultural extension work in Arkansas and later organized and became the first director of the General Extension Division in that state, is the director of the new Florida General Extension Division, which represents all state institutions of higher learning.

A PLAN FOR TEACHING THE "PRINCIPLE OF WORK" ACCORDING TO THE PSYCHOLOGICAL ORDER.

By Charles H. Watson,
University of Kansas, Lawrence.

Since it is quite in harmony with educational theory to organize the material and develop the subject-matter of any given high school course according to the order suggested by the psychological principles involved, why not change our educational practice so as to conform with our theory? The foregoing question has been asked repeatedly by professors of education and teachers of high school subjects yet the high school physical sciences continue to be taught, in large measure, according to the formal unpsychological way which has obtained in previous years.

That such a condition is acknowledged, and with regret, by many, is shown by a most casual survey of recent literature bearing upon the teaching of high school physics and chemistry. Nor do such articles stop by merely deploring the situation, for in many instances, a remedy is suggested by urging teachers to apply the principles of educational psychology. Special emphasis is frequently placed upon the necessity of leading the pupil from the "concrete to the abstract"; from the "familiar to the less familiar"; from the "applications of principles to a conception of the principle"; etc., by means of "problem solving," exercises or situations. In most cases such suggestions, however, have stopped short of being of real help to the teacher in service. Discussions of the value of such sequence or of the "priority of problems over principles," or "what constitutes a project" or the "value of the project-problem method" are fine and provoke thought but the crying need of the average high school physics or chemistry teacher is not met by such theoretical discussions. The average science teacher at the present time is convinced that such sequence should be followed but seeks in vain for a text or for material organized in harmony with such theory. What is needed, therefore, is an actual workable plan for teaching a specific body of material or for giving definite training in scientific observation and interpretation in harmony with this so-called "psychological order."

For some time the writer has been experimenting with such a plan with a class in physics in the University Training School. The success thus far obtained with respect to both interest and ability to grasp and utilize facts and principles on the part of the students is such that one is justified in adopting it in preference to the older plan.

The plan was outlined with the following items kept always in mind:

1. Begin with devices (or applications) rather than with principles.
2. If possible begin with devices familiar to the students' everyday life rather than with so-called standard laboratory equipment.
3. Do not hesitate to use a device even though it is very complex or complicated, if it is sufficiently familiar.
4. Arrange the material, as far as possible, so that the work of the student involves the solving of problems or the answering of questions.
5. Have the students perform many informal experiments with brief "write-ups" rather than a few formal experiments with elaborate notes.
6. Each experiment (or set of experiments) must have a definite purpose and place in the sequence of the development of the material in hand, hence certain days of the week can not be designated as "Lab. days."
7. Since many of the experiments are to be performed with familiar devices or machines the students will be not only at liberty but also urged, to perform experiments at home, on the farm and in the shop. Hence, provision will be made for checking out some materials, as spring balances, to the students to take away from the laboratory.
8. Provide experiments with devices found in the home, on the farm and in the industries, so as to offer a choice to the students thus providing for their individual differences of inclination and ability.

Instead of using a text-book elaborate notes were mimeographed and given each student. In teaching the principle of work in the light of the foregoing items the following plan (greatly condensed) was used:

These questions were asked at the very outset:

(a) What makes a motor car go?
(b) What makes a sewing machine go?
(c) What makes a watch go?
(d) What makes a railway engine go?
(e) What makes a street car go?

The mimeographed notes together with the class discussions regarding the answers to the above questions brought out or called attention to two facts, known in a more or less vague way to all. First, in all machines a *force* is *transmitted* by various devices from the point where it is applied to the point where it does the desired work. To impress this upon the minds of the students the following assignment was made:

In the following list answer with respect to each item these questions: Where is the initial force applied? How is it transmitted? Where is the final force effective?

1. Ordinary brake on an auto
2. Emergency brake on an auto
3. Door latch
4. Row boat
5. Signal board for trains at the depot
6. A pump
7. A flour sieve
8. A bread mixer
13. Human arm
14. Furnace grate shaker
15. Claw hammer
16. Wagon brake
17. Phonograph
18. Piano key
19. Meat grinder
20. Corn sheller

9. A wind mill
10. Raising a dentist's or barber's chair
11. A nut cracker
12. Block and tackle
21. Tinners snips
22. Cranking a car
23. Telephone bell
24. Crow bar

The second fact brought out was that there are several general sources of motive force. In answer to the first five questions these were suggested in the notes: (1) Explosion, (2) steam, (3) human force, (4) coiled spring and (5) electricity. The following additional immediate sources of motive force were also suggested: (6) Running water, (7) wind, (8) animal force, (9) compressed air. To give drill in analyzing the source of forces operating various machines the following assignment was made: In the following list of machines mark before each one the number corresponding to the above source of motive force which is most generally used. If more than one kind of motive force is sometimes used give the number of it also:

Sewing machine
Rotating lawn sprinkler
Aeroplane
Railway engine
Automatic railway block signals
Plow
Bicycle pump
Brakes on railway train
Well-wheel
Ice cream freezer
Phonograph
Windlass
Windmill
Gas meter
Jack screw
Nut-cracker
Stump-puller
Egg-beater
Crow-bar
Wheat-binder
Elevator
Railroad crossing signals
Pencil sharpener
Railway motor cars
Mechanical toys
Barber's clippers
Churn
Threshing machine
Bread-mixer
Street car
Door knob
Automobile
Steam shovel
Door bell
Sash locks
Merry-go-round
Crane or derrick
Moving picture machine
Mowing machine
Bicycle
Pianola
Block and tackle
Dentist's grinding machine
Pump
Screw driver
Typewriter
Adding machine
Tractor
Curtain Roller
Water meter
Monkey wrench
Telegraph sounder
Vacuum sweeper
Gun
Water faucet
Auto emergency brake
Water wheel
Printing press
Washing machine
Electro magnet
Harrow
Claw hammer

After thus analyzing some of the familiar machines and arriving at a working definition of "a force" the subject was developed by means of the discussions, experiments, and assignments in the notes given the students (supplemented by class discussion) in the following way:

As the various machines are analyzed, it becomes evident that each transmits the motive force acting upon it to another point than where it is applied. A very natural question, therefore, would be:

Does the motive force acting upon machines increase, decrease or remain the same while being transmitted from the first to the second point?

Answer the question as far as possible for some of the simpler machines, such as the bicycle, claw hammer, sewing machine, block and tackle, crow-bar and well-wheel, and then check the answers by the following experiments:

Experiment 1: Procure two spring balances and a bicycle. Turn the bicycle over so the wheels will be free to move. Hook one of the balances to a pedal and the other to the outside of the tire on the rear wheel, by means of a cord. Pull, at right angles to the pedal crank, with one balance until it reads almost to its limit. Note the reading on the second balance as it is used to pull back on the wheel to keep it from turning. Make three such trials and average the results. Which is greater, the force at the pedal or the force at the tire? And how much?

Experiment 2: Drive a four-penny nail about one fourth its length into a soft pine board. Fasten a strong spring balance to it by means of a wire and observe the number of pounds of force required to pull the nail. Drive the nail again to as near the same depth as possible, using a ruler to measure by. This time, however, use a claw-hammer. Fasten the spring balance to the handle of the hammer and observe the number of pounds of force required to pull the nail. Make three such trials and average the results. Is the acting force increased or decreased while being transmitted from the handle to the nail? How much?

Experiment 3: Under the needle of a sewing machine place several sheets of paper. (A few sheets can be folded several times.) Now adjust the pedal so that it is just half way down on the downward stroke. See that the needle is *just* touching the top of the paper. Push on the pedal so as to force the needle through the paper. If the needle goes through add more paper and repeat. Continue the addition of paper until pushing on the pedal causes the belt to slip instead of forcing the needle through. Now take hold of the rod directly to which is fastened the needle, and force the needle through the paper. Which was greater, the push on the pedal without forcing the needle through or the push directly on the needle?

Experiment 4: The block and tackle consists of two sets of pulleys connected by a rope passed back and forth. One set of pulleys is fastened to an immovable object and the other is fastened to the object to be moved or lifted. (As shown in diagram).

Arrange a block and tackle as shown in the second figure. On the lower (or movable) pulley hang about four or five pounds and then by means of a spring balance measure the pull necessary to raise the weight by pulling at the end of the rope. Use different weights and observe the required force in each case. Which is greater, the acting force or the resisting force and how much? Tabulate your results.

It is quite clear that if a force is acting and nothing is *moved* by it, nothing worth while (no *work*) is accomplished. If a horse pulls on something which will not move, no real work is done, but if it pulls on a small load which will move along, the farther the horse pulls the load, the more work there will be accomplished.

In this case we would call the actual *pull* of the horse the *force* (F); and the distance it walked the *distance of that force* (d). Now in a machine there is what we call the *first force* (F1) which is transmitted by means of various devices to another point where it actually does the desired work. This final force is called the *second force* (F2). It was found in the previous section that in some machines the first force (F1) decreased in being transmitted so that F2 was less than F1, as in the bicycle. In other machines it was found that it was increased in being transmitted so that F2 was greater than F1, as in the auto jack. In still other machines it was found that there was no change, as in the well-wheel. Now the question arises:

Can we then make use of some machines to do more WORK than it takes to operate them?

This involves an inquiry into the distances each of these forces actually goes in the various machines. From general observation one could answer the question regarding relative distances moved by F1 and F2 in many machines. In the clothes-wringer, for instance, the hand on the crank (F1) moves farther than the outside of the rubber rollers where F2 is operating.

Experiment 5: The Bicycle. To find relative distances of the foot on the pedal and the actual distance the bicycle moves. The distance the foot goes in one revolution of the pedal is the circumference of the circle through which it passes. This distance

can be found by getting the diameter (twice the length of the pedal crank) and multiplying by 3.142. Set the bicycle on a level walk (or any level place where there is room) with one pedal pointing down. Mark the point on the walk where the rear wheel touches it. Then push the bicycle forward, by pushing with the hand on the pedal, until it again points down. Again mark the point where the rear wheel touches the walk. It is obvious the distance between the two marks on the walk is the distance the bicycle actually goes while the foot (or F1) on the pedal makes one revolution. Which distance is greater d1 or d2? How many times greater?

Experiment 6: Set up a block and tackle similar to that used in experiment 4. Hang a certain weight from the lower pulley. Now measure the distance the acting force F1 must move in order to raise the weight a certain distance, one foot for instance. Which travels the greater distance. How many times greater?

It was stated above, that if a horse actually pulls a load along, it is doing work. It is quite true, however, that the farther the load is pulled, the more work the horse does. As a matter of fact, if the load is pulled twice the distance one time as at another, just twice as much work is done. On the other hand, if the distance is the same but the load so increased in size, or the road of such character that the horse must pull with twice the force, the actual work would then be twice as much. To further show that *work involves both force* and *distance* analyze the following illustration:

A man is pitching hay onto a wagon. The rack on the wagon is just three feet above the ground. As the load of hay gets higher the man must obviously pitch the hay higher. Will it require more *force* to lift 30 pounds of hay up on the empty rack (3 feet above the ground) than to lift it up on the load when the hay is three feet deep (6 feet above the ground)? Why is it, then, *harder* for the man to pitch the hay when the load is 6 feet above the ground? On the other hand, would it require more *force* to lift 60 pounds of hay up on the empty rack (3 feet above the ground) than to lift 30 pounds the same height? How much more? From the answers to the foregoing questions it is clear that to lift 30 pounds of hay up to a height of 6 feet required twice as much *work* as to lift it on to the empty rack, not because it requires more force but that the same force must act through a distance twice as great. In the second case the man must do twice as much work to lift 60 pounds of hay on to the empty rack

as to lift 30 pounds, not because the *distance* is any greater, but because twice as much force is required to lift the first weight as the second.

Since *work* depends upon both *force and distance*, it is customary to speak of any amount of work in terms of the force and distance involved. Thus one pound of weight lifted one foot is called *1 foot pound*. *Two* pounds lifted *one* foot would be two foot pounds of work. *One* pound lifted *two* feet would also be two foot pounds of work. It is seen, therefore, that all that is necessary in finding how much work is done in any given case is to know the force acting and how far it acted, then *multiply* the two together, remembering to attach to the answer the double word made up of the unit in which the force was expressed (as pound, ounce, gram, ton, kilogram, etc.), together with the unit in which the distance was expressed (as foot, inch, yard, mile, meter, centimeter, etc). To further illustrate: If the man lifts 30 pounds of hay up 3 feet he does an amount of work equal to the product of the 30 pounds by the 3 feet. (Force times distance) which is equal to 90 foot pounds. (ft. lb.).

Drill Problem List No. 1. Tabulate the data and answers of the following problems according to the form suggested:

1. A horse must exert an average pull of 300 pounds to move a certain load. How much work is done in moving it 250 yards?
2. The pedal crank of a bicycle is 8 inches long. A man pushes on the pedal with an average force of 70 pounds. How much work does he do while the pedal is going around 10 times?
3. If the average force required to inflate an auto tire when using an air pump which acts only on the downward stroke is 20 pounds, how much work is required to make 60 strokes if the length of the stroke is 13 inches?
4. An automobile wheel is mired in the mud. To pry it out some fence posts were obtained. When everything was adjusted a 150 pound man balanced himself near the end of the post used for a lever. The end of the pry moved down two feet. How much work did he do?
5. If the piston in the cylinder of a motor car can move eight inches and the average effect of the explosion is 900 pounds, how much work ought the piston to be able to do in the downward stroke following the explosion?

It has been shown that any force must act through a certain distance to actually work. Also it has been found that connected with every machine are two forces, F1 and F2, together with their distances d1 and d2 respectively. It is further known that the work done by any force is the product of that force by the distance through which it acts. In the light of these facts it will be possible now to answer the question which was asked, namely, if it is possible to get a machine to do more *work* than it takes to run or operate the machine? Naturally the work required to

operate a machine (input) is F1 times d1. The question now resolves itself into the question whether the *Output* (F2xd2) is ever greater than the *Input* (F1xd1). Work the following experiments and tabulate according to the form suggested:

Experiment 7: Measure the force necessary to raise a certain weight with a block and tackle. Measure also the distance the first force goes while the second force is being raised a definite height. Compute the Input and the Output. Which is greater and how much? Think of some means whereby the two could be made more nearly equal.

Experiment 8: Arrange a windlass so as to raise a certain weight. By means of a spring balance find out how much F1 must be on the handle in order to raise the weight. By measurement and computation determine how far the acting force must go to raise the weight a definite distance. Compute the input and output. Which is greater and how much?

Experiment 9: Assume that one-fourth of the weight of an automobile is lifted when a rear wheel is raised by means of the auto jack. In an actual case measure by means of a strong spring balance the force necessary to operate the jack. Now measure the distance through which this force must travel in raising the wheel four inches. Is the work done by the auto jack more or less than the work required to operate it? Tabulate.

Experiment 10: Wind a strong cord several times around a common organ stool (as shown in diagram) with a loop in the end to which is hooked a strong spring balance. Let a person of known weight sit on the stool. Observe the force necessary to raise the individual by means of turning the top of the stool. Now measure how far this force moves in raising the top of the stool one inch. Compute the work put into this machine and the work done by it. Which is greater? Suggest a means of more nearly getting the same amount of work out of this machine as it required to operate it.

Experiment 11: Arrange a board so as to form an incline (as shown in diagram). Obtain from the laboratory store-room a small four wheel iron car (called Hall's car). Load this car with any kind of weights (nails, shot, etc.), and find the weight of car with its contents. By means of a cord attach a spring balance and get the force required to pull the car by averaging readings taken at various points as the car is gradually pulled along. Also measure the distance this force must go (the length of the board) *in raising* the car to the height of the upper-end of the board. Compute both input and output.

What is meant by the efficiency of a machine?

From the results of the foregoing experiments and the definition of work it is seen that the output is as much less than the input as the amount of work required to overcome the friction in the machine itself. With some machines the work required to overcome friction is small as in the bicycle; in others it is large as in the ordinary block and tackle; with still others it is very large as in the jack screw. Constant effort is being made to reduce the friction and thus make the output more nearly equal the input. Oil is freely used, bearings are made very smooth, ball-bearings and roller-bearings have been invented all in an effort to reduce friction and thus have less waste in transmission.

This gives us a basis for rating the *efficiency of* a machine. If the output were actually equal, which is never absolutely the case, to the input the efficiency would equal 100 per cent. If, as in some machines, three-fourths of the input is wasted in overcoming friction thus making the useful work done or output but one-fourth as much as the input the efficiency would be 25 per cent. In brief, the efficiency represents the per cent or fraction of the input, which is actually transmitted and appears as output.

Thus: Efficiency equals $\frac{Output}{Input}$

As has been shown a machine transmits a motive force from one point to another; this force being sometimes greater, sometimes less and sometimes unchanged after being transmitted. *In the same way WORK (or ENERGY) is also transmitted.* But in the case of transmission of energy, that which is transmitted is always less than that required to operate the machine. In other words the output *is always less than* the input. Were it not for friction in the transmission, however, the output would equal the input. As the term output is here used it means the *useful* work done by a machine. If the work required to overcome friction were also included in the term the statement could be made, *output always equals input.* This is called the *Principle of Work.* Since the former definition of output is the better one, the Principle of Work can be stated thus: Output plus work done to overcome friction is always equal to the input. This has become so well established that no scientist of today believes in the possibility of a machine with perpetual motion. A machine in order to operate perpetually would have an input less than the *output plus work done* to overcome friction which is contrary to all our past experience.

THE RECORD SHEET FOR SCIENCE COURSES.

By C. H. Farr and R. B. Wylie,
University of Iowa, Iowa City, Iowa.

Laboratory work is indispensable to proper training in the various branches of modern science. It is in the laboratory that the student, supposedly, at least, receives the individual suggestions of an instructor, and it is there that he familiarizes himself with the methods of independent observation and experiment. The latter is by far the more important; the presence of the instructor is essential only in so far as he assists in bringing about independent work on the part of the students.

Unfortunately for laboratory work these ideals are not always realized. Too frequently the student leaves the laboratory with a feeling of uncertainty, having attempted a series of performances without realization of their meaning. Not only is there uncertainty as to whether experiments were properly carried out, but he may never learn whether he arrived at the conclusion properly to be expected. The student approaches his next exercise with little hope of a better understanding and soon acquires a careless attitude towards his laboratory work; he is serving a sentence for so many hours per week in the laboratory rooms. Reports are often carelessly written and with little regard for the English language which another department meanwhile is trying to develop.

This is perhaps too gloomy a picture for the average condition in our schools, but it is found frequently enough to give teachers of scientific subjects pause in the planning and the execution of their laboratory program. The standard and quality of laboratory instruction in science in our colleges and universities to say nothing of the secondary schools has been on the downward trend during the past few years. The war period brought peculiar difficulties for laboratory instruction. Various lines of military service reduced the number of teachers and the general disturbance of the time lowered the morale of the class room. Laboratory apparatus was difficult to get and often below standard in quality. With the coming of peace we entered upon a reconstruction period that still taxes the best efforts of our schools. Finally, the great increase in the number of students as compared with the number of available instructors has resulted of necessity in the employment of relatively inexperienced laboratory assistants.

The student thus finds the laboratory no longer a place

for personal contact with the professor; instead he must work ahead more largely on his own responsibility with such help as he can obtain from the assistants in charge. There is still a question as to whether the student will not get farther in training in independent thought and action than under the former system. The chief difficulty with the newer situation is not so much that the assistant lacks interest or ability but that being inexperienced he finds difficulty in giving the individual student information regarding mistakes and ways of improving his work in the future.

In many of our colleges and universities, and this is especially true in laboratories of botany or zoology, the student works day after day and does not file his notebook with the instructor until the close of the first semester or term. It is then graded and returned to him sometime during the second part of the year. No helpful remarks or suggestions are made upon the notebook and in some institutions even the grade is not revealed. The student thus has no way of knowing the degree in which his work is satisfactory and what is doubtless still worse, he does not know his errors nor how his work can be improved. In some instances notebooks are graded oftener but frequently nothing is given the student except the information that his work is or is not acceptable, with little to direct and aid his further efforts. There is probably nothing more discouraging to a student than to know that he has failed and not to know wherein he has erred nor how such errors may be avoided. All students welcome criticisms, whic are constructive, and are anxious to learn the reasons for their failures and mistakes.

The English teachers need and should have t e cooperation of all other faculty members in promoting a correct use of the language. It is too much, of course, to ask that teachers of science become theme readers and correct each mistake, but they should call the attention of the student to faulty English and deduct from his grade for errors of this type. All teachers are glad to give such assistance, if it can be done without adding greatly to their work. Indeed, it is found the improvement in the legibility and readability of the student's work compensates for the effort put forth to bring it about.

Furthermore the decrease in time and attention given to mathematics in the high schools has lead to difficulties for our University Freshmen in measuring objects, computing their surfaces and volumes and describing their form. The average

student in the first year of science work describes nearly every object placed before him as either "round" or "oblong."

With the hope of avoiding at least some of these difficulties of laboratory work the authors have adopted the following plan and put it into practice in their Freshman course in Botany at the University of Iowa. So successful has been its operation that we gladly recommend its trial by others. It is especially adapted to courses in botany, biology, agriculture, zoology and general science, and might be modified for use in other courses in scientific subjects.

The student at the beginning of the course is given full directions as to the general method and procedure of the laboratory work and in addition is, of course, given specific instructions for the work of each day as it comes. At the close of the first period he places his laboratory work for that day, consisting of notes written in ink and drawings made in pencil, in a large envelope together with a copy of the following record-sheet properly signed and dated. This envelope is then left in a receptacle in the laboratory which is arranged for that purpose.

DEPARTMENT OF BOTANY, UNIVERSITY OF IOWA.
Record-sheet for Laboratory Exercises

Signature———————————————Date———————

Note: When this sheet is returned take note of those———————
items that bear a check of the color opposite the date on———————
which this sheet was last filed. File this sheet with each———————
exercise placing the new date on the next line. No credit———————
will be given for work here represented if checks are———————
erased.

	I. Notes.		
1. Inaccurate	*Descriptions*	*Calculations*	*Conclusions*
2. Statements	*Too-brief*	*Too-extended*	
3. Sentences	*Incomplete*	*In First Person*	
4. Indefinite	*Words*	*Phrases*	
5. Report	*Not-outlined*	*Incomplete*	*Crowded*
6. Notes from	*Books*	*Neighbors*	*Outlines*
7. Cooperation in laboratory		*Too-much*	*Too-little*
8. Technical terms	*Misspelled*	*Incorrectly used*	
9. Written with	*Pencil*	*Defective Pen*	
10. Penmanship	*Illegible*	*Not-neat*	
11. Pages	*Not-in-Order*	*Not-numbered*	
12. Incorrect	*Spelling*	*Punctuation*	*Grammar*
	II. Plates.		
1. Plates	*Soiled*	*Inverted*	
2. Omission of	*Name*	*Date*	*Number*
3. Labels	*Omitted*	*Keyed*	*Incomplete*
4. Legends	*Too-Large*	*In Ink*	*Not-neat*
5. Drawings	*Too-crowded*	*Not-consecutive*	

6. Drawings on	*Same Plate*	*Separate Plates*	
7. Index-lines	*Not-dotted*	*Crooked*	*Indefinite*
III. Drawings.			
1. Arc	*Incomplete*	*Inaccurate*	*Careless*
2. Arc	*Unproportionate*	*Not-diagrammatic*	*Diagrammatic*
3. Size of drawing		*Too-small*	*Too-large*
4. Lines *Angular*	*Unsteady*	*Heavy*	*Indistinct*
5. Drawing	*Too-detailed*	*Insufficiently-detailed*	
6. Drawing Number		*Omitted*	*Copied*
7. Shading	*Not-neat*	*Too-elaborate*	
8. *Similar cells*	*Too-few*	*Too-many*	
9. Scale of related drawings		*Not-uniform*	*Uniform*
10. Cell-content should be		*Included*	*Omitted*
11. Cell-walls should be represented by *one two* line(s)			
A check on this line indicates that the work is deficient————			
A circle on this line indicates excellent work in all respects————			

The record-sheet consists of a list of those errors and omissions that occur most frequently in laboratory note-books. While it is used to record mistakes it carries by inference very definite suggestions as to how the work may be improved. The suggestions are brought to the attention of the student through the visual rather than the auditory sense, and in the majority of cases the former is the more effective. All criticisms are individual as each student has his own record-sheet. A given Record Sheet is used for as many as six successive periods so that the student has brought to his attention, much of the time not only his errors in the latest exercise, but also those of preceding periods. This repetition of criticism aids the student in eradicating his major faults, since repeated checks indicate persistent tendencies in his work.

At first thought it might seem that such a list would suppress originality in the student and make him a mere automaton. This danger has not developed in our experience with this plan; on the contrary a prize is placed on individual effort. A single sketch placed on the blackboard in the laboratory or a single chart on the wall is found to be far more detrimental to individuality than is the use of the record-sheet. In fact the record-sheet insures the accomplishment of the first principle of laboratory instruction, namely, that of *helping the student to help himself*. Check marks refer to the points in which he has erred and which he should seek to correct; attention is drawn to his mistakes without doing the work for him or making the laboratory work a mere matter of transcribing notes and drawings.

The instructor under whom the student works in the laboratory goes over the report, checks the points on the record-sheet and returns these to the student at the beginning of the next laboratory period. In this way the student's own papers are kept

free from defacing marks by members of the teaching staff. The first thing the student does upon entering the laboratory is to look over his work of the preceding period in connection with the record-sheet, noting any mistakes he may have made. Incidentally he also usually has called to his attention mistakes which he had previously made and has been endeavoring to overcome and this helps him to perpetuate his new attainments of neatness, orderliness, and good English so that they tend to become habits.

In case of inadequate information on the record-sheet, or if the application of the check to the work is not plainly understood, the instructor is at hand to answer the questions. However, experience has shown that the record-sheet is usually quite adequate for conveying the proper meaning to the student. Some of the items are purposely made vague in order that supplementary oral instructions may be given the individual student to whom they are applied. Instead of supplanting necessary oral instructions we have found that the record-sheet insures that such conferences are not over-looked by leading the student to call the instructor's attention to them.

The first day's work is checked on the record-sheet in blue pencil. At the close of the second period the student files his work and with it the same record-sheet upon which he has placed the new date. This time the assistant uses a green pencil. The third time yellow is used, then pink, red, and brown in succession. The record-sheet thus covers six laboratory periods. At the end of this time a new record-sheet is issued to each student while the old one is filed again and retained by the department as a permanent record of the student's work over this section of the course. Rare indeed is the student who will not show improvement after a week or two of a record-sheet showing no progress. And quite as rare also is the student who has reached such a degree of perfection that he has at the close of his sixth period a record-sheet entirely free from check marks. For such a student we have thought it desirable to have a still higher mark of distinction for which he can strive after he has obtained a clean record-sheet. The last line on the record-sheet is to be used only at the end of the several periods which the sheet represents and then only if no check marks have been necessary, and the work is of even higher merit than the absence of check marks would indicate. Between this mark of super-excellence and the deficiency mark indicated by the next to the last line there is a very wide range clearly

indicated by the record-sheet. Students presently find themselves at some level and can daily mark their retrogression or advance.

At stated periods the student files his completed note-book with the necessary amendments of the notes corrected by repeating, if possible, the observations. At this time the assistant places the following blank form by the aid of a rubber stamp upon the latest completed record-sheet and files all of the record-sheets at hand with the professor in charge of the course after filling out the form, except for "Grade" and "Rank."

Scholarship————	Ability————	Grade————
Improvement————	Attitude————	Rank————
Absences: Excused——	Unexcused————	Made up————

Scholarship is interpreted as indicating the actual value of the work which the student does irrespective of all other considerations. Ability is that which the student is capable of doing under ideal conditions and with the best effort possible. Attitude covers such considerations as whether the student likes laboratory or not, whether the subject matter or instructors appeal to him, whether he is stimulated by a feeling of pride in his work and is putting forth his best effort to achieve or if he is simply working for a barely passing grade. In general it is likely that scholarship will be a resultant of attitude and ability. The grade is based on all of these points taken together and is further affected by the final notebook which is handed in at the close of the term with the drawings inked. Rank is recorded numerically and is determined by arranging the notebooks in the order of their quality and numbering them, the best notebook receiving the number one. Like grade it is based on a consideration of the student's work from all angles.

The professor thus has at his disposal the completed notebook, the record-sheets and the report of the assistant in charge of the laboratory upon which to base his judgment as to the grade of the student in addition to his own personal experience and observation of the student's work. In cases where the professor is also personally in charge of the laboratory and looks over the notebooks daily himself the matter is simplified somewhat but the general plan might be used with profit.

In actual practice it is found that the students are very favorably disposed toward the record-sheet plan. There were at first some misgivings in the minds of the instructors that such a formidable list of "sins" might have a depressing effect upon the members of the class. On the other hand it was found that the

record-sheet had an effect which was decidedly stimulating. Very rare was the case in which the number of check marks did not decrease during the first few exercises, and it was not long before the students were vying with each other to keep the record-sheet as free from checks as possible. This was even carried so far in one or two instances that students preferred to receive *one* check mark for "drawing omitted" rather than hand in a drawing and have several mistakes recorded by checks. Of course, care must be taken to explain that the checks are not considered of equal weight. However, the errors are so arranged on the sheet that under the three headings the more serious ones are placed first and those of lesser importance from the standpoint of work in a science course toward the end of the list. Thus a glance at the record-sheet does indicate to the experienced instructor something of the standing of the particular student to whom it belongs.

Not only is the record-sheet well received by the students but also by the members of the staff of instruction itself. The assistants feel that the improvement in English and in the general form and clearness of the reports entirely repays them for the time and effort in checking over the work each day. They receive much valuable experience in critically going over the work of each individual student and studying their progress from week to week. Such experience is the best training for those preparing to teach or enter similar professions where a study of human nature and achievements is involved. The results of our experience with this plan with Freshmen amply warrant us in continuing its use in our classes and extending its use to other more advanced work.

ALUMINUM PRODUCTION.

The value of primary aluminum produced in the United States in 1920, according to reports received by the United States Geological Survey, Department of the Interior, was $41,375,000, as compared with $38,558,000 in 1919. This increase of approximately 7 per cent shows a return to more normal operations and indicates what may be expected in the future. The market prices throughout the year have been nearly constant, ranging from 32 to 33 cents a pound.

During 1921 the aluminum industry will no doubt continue to grow, for the South American deposits of bauxite, the ore of aluminum, are now yielding a regular output, the domestic deposits are being worked more advantageously, and the aluminum plants in North Carolina and Tennessee are producing more metal from year to year.

SOME ASPECTS AND PROBLEMS OF HIGH SCHOOL BIOLOGY.[1]

DR. N. M. GRIER,

Washington and Jefferson College,[2] *Washington, Penn.*

The biological sciences of botany, zoology, and physiology share alike in the condemnation implied by the decline in the number of students taking them in recent years. The popular demand upon our public schools in America at this time is for any type of training which directly prepares the student for self support. When viewed from such an angle, it is not surprising that the required study of biology in the high school has to the average person the same apparent futility he associates with the naturalist "chasing butterflies." That, however, involves a factor which biologists at least are able to appreciate—that of the utilization of the butterflies for some useful purpose. It is probably true, therefore, that those who are interested in the rejuvenation of high school biology, will find a key to the situation through the invocation of such a factor. Later on, evidence will be presented which indicates that biology teachers themselves are largely responsible for the conditions which have reduced the science to a comparatively insignificant position in the secondary school.

As teachers, we are all prone to believe that our work with the educative mechanism reacts solely upon our pupils. Should this alone be the case, it must occur to us, that our efforts have not been very successful. But we are very apt to forget that we also influence to large extent, the ideas of our colleagues and administrators along the lines in which we work, and their picture of biology is, to a great extent, a reflection of our efforts. Here again we must admit we have failed, for if we do not receive the approbation of our associates, we can scarcely expect it from the public. A previous speaker at this meeting has stated that high school principals are today stressing either physics or chemistry, because their science work in college consisted of these subjects, instead of biology. The statement has also been made that biological subjects are being taught in so-called laboratories, rooms without facilities for laboratory work, and that in some cases, teachers without special preparation are put to teach these subjects, although only especially trained college and university graduates would be allowed to go before

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[1]Extract from paper read before the Section of Biology, Education Association of Western Pennsylvania, January 22, 1921.

[2]Contribution No. 71, (Edwin Linton and N. M. Grier) from the Biological Laborator Washington and Jefferson College.

the classes in the other sciences. All of this is additionally true, but the fact remains that if biology teachers had been able to give a larger view of their subject, such makeshifts would hardly have been foisted upon the science. In toto, the result of this lack of appreciation has been to give biology the status of an elective subject in the high school—a situation we all earnestly deplore. For his part, the administrator is already half convinced that his sole obligation in the matter has been satisfied when provision for the subject has been made solely for those who specifically desire it.

We can scarcely believe that most parents in America, let alone their children, are in fullest sympathy with the educative process as a whole. The truth of the matter is that the economic, social and intellectual situation is such as to render unpopular any form of education involving constant mental effort, unless the latter be carefully camouflaged. For his part, the biologist is well aware that any *well taught* science can be any other than disciplinary, however velvet the glove. Despite this apparent conflict in ideas, we must never forget that the public always returns to the profession for leadership in educational matters, and the sooner we put ourselves in a receptive mood the better. The public asserts its preference in educational matters only under the stress of disturbed social and economic conditions. Neither does it fail to recognize ultimately the efficiency of a given kind of instruction, if such exists. At least we have all recognized the fact that the adolescent is usually a poor judge of just which subjects he should select in the high school.

Biologists have a peculiar sympathy with the cause of education, because the latter is essentially a biological process. It is a matter of regret that the majority of those educational specialists, who have played a large part in the reorganization of the public school curricula, have not had more extensive biological training. Let no secondary biology teacher feel that opportunities are wanting for him, for the biological aspects of education represent uncharted seas. For the present let us compare older and more modern definitions of what education should do for an individual and what it should consist of. The older is the product of Huxley, the pioneer teaching biologist, the younger is based on the biology Huxley so well inspired, although somewhat tinted with the faddishness of the day.

Huxley says: "That man, I think, has had a liberal education, who has been so trained in youth that his body is the ready

servant of his will and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature and the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness, and to respect others as himself. Such an one and no other, I conceive, has had a liberal education."

The following definition of Education is set forth in the pamphlet entitled "Cardinal Principles of Education" by the National Committee on Reorganization.

"Education as a democracy, both within and without the school, should develop within each individual the knowledge, interests, ideals, habits and powers whereby he will find his place and use that place to shape both himself and society toward ever nobler ends."

We have seen wherein our relations with the public principally involve motives of consideration, tact, and service on our part, if we desire biological sciences to regain their old standing, since without the public's support we may not most fully develop a disciplinary conception of the science. Personally, I have no sympathy with the idea that all secondary science teaching should be from the psychological, rather than the logical basis. In fact, both are desirable, the former by way of introduction to the full significance of secondary education, the other by way of preparing the individual for the mature type of thinking, too often absent in adults today Our relations with administrators are different. Educationally speaking, while the latter are usually conservative, the recent reorganization has temporarily given them the aspect of progression. Our thesis is that an improvement in the high school curriculum was not made by placing biology on an elective basis, as judged by the past and present criteria of education.

When we return to the relation of the biology teacher to the problem, we find that it is the opinion of leading biologists who have become administrators, that the decline in the number of students taking biology is due to ineffective teaching. This is un-

doubtedly the case to a large degree, but it will be remembered that until recently few teaching courses in the subject have been offered in the colleges and universities. While many enthusiastic biology teachers have placed their own experiences and observations in print, others have not, and those of the former have not been read. Not only that, it appears inherent in biological science to suffer certain handicaps in its teaching, both in methods and in content of material taught. Thus one contributor states, "secondary pupils do not undertake certain studies of the living animals, and plants, with the enthusiasm and earnestness characterizing similar studies in the grade school." In reply it might be stated that an unenthusiastic teacher might expand but little on the knowledge of biology gained by nature study in the grades, while one alive to his opportunity would ascertain by psychological tests or a general type survey, approximately what the pupils had had, and thus save time for the live things of the course. Vitalizing biology depends upon the background the teacher has had. Under ordinary conditions, one could consistently take the standpoint that since no form of life is more abundant than plants, there should be no insurable difficulty in making the teaching of botany more effective. Secondary physiology has also been criticized to the effect that "it added nothing but technical terminology and anatomical detail to the material already obtained in the grade. Somehow, the old reliable physiology of biologists has held its own in reorganization, and has blossomed forth under the title of "Health Education." Essentially, the latter is the life-like, efficient physiology teaching a few teachers have performed for years. Biology teachers themselves have disagreed as to the content of the course in zoology. The entire situation from the organization standpoint is further complicated by the fact that nature study in the schools is just starting to develop. To teach efficiently in the meantime, high school biology teachers must continually adjust until nature study is more stabilized. It ought to be possible for some of the biologists in a school system to devote attention to this matter, even if they do so only to keep alive that inquiring spirit which characterizes the real teacher.

It is regrettable that truer democracy in education has not extended to every phase of educational work. The "inquiring spirit" among secondary teachers has been tacitly discouraged, as tending to disturb the equilibrium of the school system. When

all other things were apparently equal, scholarship and research, largely the fount of personality in the teacher, were regarded as the school systems' liabilities rather than assets to be judicially invested. Reactions to such conditions are represented in the prevailing scarcity of biology teachers throughout the country.

If, as indicated, biology possesses no attractions for most students beyond the earlier years of adolescence, it is probably true that, due to their manifold application in every day life, physics and chemistry are more successful in retaining the liking of students, if such be the criterion whereby the value of a subject to a student is measured. The gripping power of these subjects is, however, not due to any superiority in the amount and kind of material available, when compared with that of biology. Administrative difficulties have deleted much of the vital material of biology, sometimes with the courtesy of a genuine excuse. At other times, idiosyncracies may play a part. Thus, one high school principal desired that the study of the tapeworm be omitted as, "it might cause morbidity among the students!" Sex education has been barred for similar nonsensical reasons, just as if pupils did not obtain inaccurate and harmful information on the subject outside of the schools. Nothing disguises the fact that this last sin of omission on the part of the public schools runs but little short of malfunctioning. Even at this time, the impersonal agency of the government must assume the responsibility of this type of biology, solely because the public, and, in turn, administrators have not come to know what biology really means to the life of the individual, and, therefore, the nation. It seems clear that the problem of the maintenance of biology in the public schools is in its simplest terms, one of arousing the attitude of appreciation in those whom it would benefit.

The matter of securing appreciation for biology must first be the work of the individual teacher. Teaching biologists have so studied the ground that a great variety of textbooks constitute primary material on which to draw. In botany, for instance, textbooks dealing with some applied form as agriculture are available for rural districts, where they are more apt to be desired; for cities and larger towns where often more purely cultural values seem to be rated higher, there are others, colored with the philosophical aspects of botany, such as plant ecology. He who would be a successful biology teacher must

disregard the current type of discouragements, and seize every opportunity for further study, so necessary for the background of teaching. The rural teacher will find that the extension or correspondence service of colleges and universities can largely guide him in his studies. A greater sympathy now exists between higher institutions of learning towards the problems of the secondary school teacher. Teachers' courses, embracing the efficient short cuts in teaching, are now offered, and best of all for the profession, the college professor no longer regards his brother of the secondary schools as being of an inferior educational status, for he has learned that he may acquire teaching points from him.

Let the biology teacher launch himself ahead with the determination that he will make something or other of his present opportunities, with the full conviction that if he is teaching biology for biology's sake he will get out of it what he puts in. Let him seize every opportunity to make his subject the medium whereby existing public evils peculiarly related to his field are brought to the attention of the public and corrected—in short, attempt the civic and social biology so well dealt with in recent textbooks. Let him make the biology of his classes function as an outlet for every other subject of the school curriculum. Let him visit other teachers, exchange ideas in professional conferences, and be on the alert to constantly profit by the ordinarily considered insignificant peculiarities of the situation —that boys as a rule form more accurate concepts than girls, physiology is the most difficult of the high school biological sciences, physiology and zoology are subjects appealing most to the boy mind; botany to the girls. The development of such a spirit soon renders the teacher superior to his pay check, and without him knowing it, places him in line for a bigger one. It is thence but a short step to the organized effort of all teachers of biology by which that subject may regain the status indicated by Huxley. It seems most fitting that in conclusion the following extract be quoted from the recent report of the biology teachers of the Chicago high schools for a new course of study:

"We hold that biology is unique among secondary school subjects, when properly taught, in serving a greater number of the ends of education than any single subject and that it should furnish a part of the training of every boy and every girl who is to contribute to the depth and breadth of the democracy in which each is later to take an active part."

SOME OBSERVATIONS CONCERNING THE HISTORY OF SCIENCE.

By E. H. Johnson,
Kenyon College, Gambier, Ohio.

There is little doubt that man's greatest object for study is man himself, and that human supremacy over nature in all its departments constitutes a natural and necessary aim, if man is to ascend to still higher levels in his evolution. But the collective experience of the human race seems to be one of recurring sadness owing to the failure to recognize that a lasting ascendancy is not to be gained by any attempt to make stepping-stones of other individuals or of other nations. The primitive man within us still bristles and finds a measure of delight in tales of old conquests. Many ideas appear meritorious in direct proportion to their antiquity. The dearest treasures of countless modern institutions have had a common cradle in some far past when man's half-growth demanded things which are no longer of nutritive value. Each new war seems to start and end on about the same spiritual level as did those of three thousand years ago. They have resulted in little permanent good. And yet these are the things that have largely filled our histories up to a very recent time. The one line of human development most inseparably connected with all that present-day civilization embodies has been quite neglected. It is the history of science.

Contemplation of the efforts and the sacrifices of the men who have contributed most to our present form of life, surely goes further than can any study of military or political trickery to arouse in the growing boy or girl a spirit of optimism and altruism—an almost religious consciousness whose fundamental aim is to help in this world-old and therefore greatest of movements—to make the world a better place in which to live, and to make the living an ever fuller thing. The history of science, when considered in anything like its entirety, becomes a history of the intellectual rise and development of mankind. With its many points of contact with all phases of human growth, it becomes a story of the rise of civilization itself.

In any attempt to select the valuable from among the trivial in the records of pioneer achievements, only a careful and painstaking analysis can lead to trustworthy conclusions. And such a study should be strengthened by a very complete knowledge of the subject as it is today. It is doubtful if the general historian is capable of writing unassisted the history of an exact science, for the simple reason, that he has not had the

training that is requisite to enable him to think critically along this special line. He is apt to be unable to command the viewpoint which alone was the prominent one to the original investigator.

On the other hand, it need not be denied that the scientist, owing to his very intimacy with the scientific way of thinking, may be incapable of gaining the broadest possible view and of making the unprejudiced survey which is undoubtedly the duty of every writer of history in so far as possible. He realizes fully that he is liable to be criticised for some of his methods of historical research, for they will possibly lack the trade-marks of the historical guild. His ways of procedure may be new in the field of historical investigation, but he is not called upon to overlook the other fact, that the historian who is unfamiliar with the facts of present science and the laws of order and sequence that obtain in the several departments of natural phenomena, is certainly no more capable of writing the story in an ultimately acceptable form.

These weaknesses are, however, perhaps no more than normally human, for as Carlyle observed, "Histories are as perfect as the historian is wise, and is gifted with an eye and a soul." But there is apparently no reason to believe that some ground for joint action may not be found so that the combined efforts of a large number of investigators in both of these classes may result in the gradual shaping of a story of this phase of human endeavor that shall approximate the truth and in which there will remain no undue distortion of perspective. Many of the finer points will have to be settled little by little as best they can by the already proven methods of historical research. Here the trained historian will find his own fitting service. In the meantime, the scientist and the teacher of science can do much in this great field in unfolding to the best of their abilities this most certain story of man's own growth. They need have no great qualms about the acceptableness of their methods so long as they follow in the lead of the very men whose lives they are seeking to reveal. Sincerity of purpose will make pardonable a multitude of historiographical sins.

A study of the past—again with the scientific development in mind, in particular—shows that many ideas, which we may have come to consider as quite modern, are not new after all, but that they were formulated at some far past time and possibly did not survive because conditions were not propitious. Or what is more

likely, they were lost in the social upheavals that have ever been turning the world upside down. On the other hand, they may have filtered down through the ages, gathering influence with the centuries, and exerting it in their progress until we now find them fundamental in our whole organization. Thus, the present can be more faithfully understood when viewed against the broad background of the past.

Proper balance—in the study and teaching of this new history—must, of course, always be maintained between the importance of past events and those now in full swing. By continually pointing out the present-day results of any great discovery and showing how much its influence has been broadened with the passing years, the teacher of science history will preclude the possibility of the student's falling into the not uncommon error of thinking that all golden ages are past. The latter will soon discover for himself that the scene is continually growing brighter and brighter as he follows it out of the earlier years and down to his own day, and his now eager mind will need little further guidance to perceive the greater glory that lies on and on ahead.

Again, actual experience in classes where the history of science has been studied with possibly more emphasis on its underlying philosophy and on the human elements involved, than on the informational subject matter, has proven its power to arouse and hold in the student's mind the healthy interest best calculated to find pleasure in the study of the really technical phases of current science. This value to education in specific fields affords material for a longer discussion than is at present contemplated.

Perhaps no historical study has a more instructive bearing on the problems of the future than has this in science. Its heroes are from all classes. It reveals science as so thoroughly dynamic that no one can question its continued progress. The optimism which it fosters can scarcely be equalled by any other agency. It knows neither creed, nor nationality, but works consistently and cumulatively for the common good.

The story of the birth of a great theory or of the discovery of a fundamental law shows the student that such things are not evolved haphazard from mere dream stuff, but are the just rewards for great efforts. The survey proves truly historical in that it discloses to him a wholly understandable process whereby the various evolutionary—and sometimes, revolutionary—steps were taken. He gains something of the true scientific

viewpoint. "Mystery" ceases to have meaning other than "forgotten" or "not yet found." The mere fact of the existence of a phenomenon suggests at once the possibility of its explanation, and hence of its value.

This is not the first time it has been pointed out that one of the weaknesses in present education "is in the absence of the historical sense and the want of knowledge of the great researches upon which the edifice of science rests." This historical method of approach is, in many subjects, the most natural one for the beginner. Material thus drawn upon will necessarily be fragmentary and auxiliary to the subject-matter in hand. However, if after having acquired some familiarity with the general content of a science, the student then turns to its history, the knowledge he has already gained takes on a new and hitherto undreamed of significance. He can not but adopt a new scale of values. As he looks back, he sees that the "giants in those days" were not always those to whom their fellows looked up. False and artificial pedestals have since then crumbled, leaving each figure on the landscape at its own true height. The lasting things are seen to be those which bear up under the ever increasing weight of the superstructure. Contemporary judgment often failed in the selection of the stone destined to be the head of the corner. At our distance the perspective is freed from the violence of the "close-up" view. The tendency of such a survey is to develop in the student a calmer judgment, a toleration for opinions and institutions, a freedom from superstition, and a more unbiased valuation of all human efforts. This means that he has—if he will but develop it—the nucleus for a wholly constructive program of living. He is less liable than otherwise to fall into the narrow ways of those bygone ages when there was less of altruism and forbearance than is common even now. He comes back from his survey of the past with a more understanding vision for having looked a little beneath the surface of things with these first investigators, and he loses nothing by the occasional discovery that they were only human. Never again can his life philosophy be wholly based on the status in quo, for he is compelled henceforth to view everything—himself included—as natural phases in a never-ending sequence of events. He understands a little the causes of conditions as they now are, and he knows from the experiences of those who have labored in the age-long past, how he may help in the unfolding of the greater things yet to come.

TEACHING CHEMISTRY BY THE PROJECT METHOD.

By Ellinor Garber,

Shortridge High School, Indianapolis, Ind.

One can not spend a year at Teachers College and have work with Dr. Kilpatrick and Dr. Woodhull without becoming interested in the possibilities of the project method. The writer was, therefore, very glad to have an opportunity to try the experiment of conducting a high school class in chemistry in this way.

The class numbered fifteen, twelve girls and three boys. The smallness of the class, together with the fact that it was scheduled at an hour when it could have the exclusive use of one of the laboratories, made the conditions favorable for project work. In the first semester this class had completed the usual work on combustion, oxygen, the atmosphere, nitrogen, the gas laws, the composition of water, and hydrogen. The first weeks of the second semester were devoted to the presentation of the atomic theory, formulae and equations, with laboratory work on hydrogen chloride and chlorine. As sodium compounds were next to be studied, the following list of projects was made covering that subject.

1. How is baking soda made? What are its uses?
2. What is baking powder? What different acid substances are used in baking powder?
3. How is soda ash made? What are its uses? How can caustic soda be made from it?
4. How is soap made?
5. How is glass made? What are different kinds of glass used for? How are different colors obtained in glass?
6. How is oxone made? What are its uses?
7. What useful products can be obtained by the electrolysis of common salt? How is metallic sodium prepared?
8. Where is sodium nitrate found? Why is it an important substance? For what purposes is potassium nitrate used? How may potassium nitrate be made from sodium nitrate? How may nitrates be obtained from the air?

From this list the class chose their subjects. A first and second choice was indicated so that all the projects might be covered. It may be of interest to note that the first was the most popular, being the first choice of five girls. The seventh came next being selected by three girls and one boy. For each project a card was made out, giving the references in the text,

the laboratory manual, other referencebooks including industrial chemistries. These were given to the pupil as a starting point, and on the completion of the project each pupil was asked to add to the list any material that he had found for himself. The pupils were made to feel that the title of the project and the card of references were suggestive, to be used as a starting point, the direction and scope of the project to be determined largely by the pupil himself.

The class remained in the laboratory daily until the projects were well started. During this time the teacher had consultations with the individuals or groups, getting from them a report of work accomplished, helping them with difficulties and suggesting further work. At the final conference the pupil outlined the project as he intended to present it, or if several had been working on one project, they subdivided their material so that each might have a part in the report. They prepared a list of questions covering their project which the rest of the class answered in the note-books, after the report had been made.

The recitation time was occupied with the reports. The pupil took complete charge of the recitation, presenting his project, giving his references, performing illustrative experiments, and answering the questions of the class. When his report was finished, he dictated the questions covering his subject.

In the same way, the following list of projects on calcium compounds and neutralization was prepared and reported on.

1. How is quick lime made? What is plaster? Mortar?
2. How is plaster of paris made? How is it used in making casts?
3. What is hard water? How is it formed? How are limestone caves formed?
4. How does the Indiana Refrigerating Company soften hard water for use in its boilers? Why must hard water be softened before use in boilers?
5. How is sulphuric acid made? How is it used in making other acids?
6. How is slaked lime made? How is it used in making sodium hydroxide? How is it used in making ammonium hydroxide?
7. How may acids be counteracted? How would you remove an acid spot on clothing? What would you do for a person who had swallowed an acid? What would you give a child who had swallowed lye?
8. How can you determine the per cent of acetic acid in vine-

gar? How can you determine the per cent of ammonia in household ammonia?

For the last projects of the term, a list of wider range was given, including such subjects as metallurgy, electrolysis, compounds of nitrogen. The pupils were not given cards with references, but were required to rely on their own initiative, and the acquaintance with the department library that they had acquired in connection with their first projects. The end of the semester came before these third projects were completed.

The chief effect of the method was a change of attitude on the part of the pupils, much more activity and interest resulted. A teacher in a project class often feels that he is running a three-ring circus, but the feeling of being pulled several ways at once by interested demanding pupils is certainly better than that of dragging a more or less inactive weight.

Variety can be obtained in this work, as apparatus can be devised for one or two pupils, which could not be obtained for a whole class. Glass-making proved particularly interesting. My first pupil tried it with a small muffle furnace, and a blow pipe connected with a motor blower. The noise of the blower made it impossible to run the furnace when a class was in the room, and the short heatings were not satisfactory. Another batch was mixed and taken to the Art Department to be fired in the kiln. This gave better results, and the workers learned from the art teacher much about the coloring of glass. They returned to the laboratory, and tested out the different colors by making borax beads. Another teacher in the department obtained the best results, using a Meker burner with a small furnace of sheet asbestos. This could be set in one of the hoods, and the charge heated continuously for a long period of time. The whole class became so interested in glass that the report of the glass-worker had to be completed by a trip to a glass factory, where they studied the process on a commercial scale, and saw the annealing, blowing and molding of glass articles.

The pupils are quick to notice inter connections between their work and that of other members of the class. General principles can be brought out by these comparisons. For example the interchange of components of two salts in solution was illustrated in the making of baking soda, the reaction of baking powder, and the formation of potassium nitrate. After the work on the sodium projects had been reported on, the chapter in the text was assigned, and a review recitation was con-

ducted by the teacher. A written test was given on which the grades of the class compared favorably with previous test grades of the same class. A laboratory test was given by using the materials studied in projects as unknowns for identification. Only one pupil in the class failed to identify his unknown.

Another advantage of the method is that it gives the pupil working intensively in a small field a chance to learn to use the reference library. In fact a good department library is a necessity in doing this work. Such books as Thorp's Industrial Chemistry, Molinari's General and Industrial Chemistry, Leach's Food Inspection and Analysis were in constant use in the completion of the projects. Brownlee's Chemistry of Common Things and Weeds' Chemistry in the Home were good starting points as they connected the things of the laboratory with the things of every-day life.

From the result of this experiment the writer feels that the project method has decided advantages, and that its disadvantages can be lessened and eliminated as its application is studied and its technique improved. When conditions such as large classes or insufficient time in the laboratory prevent conducting the class wholly in this way, a list of projects supplementary to the regular work could be prepared. This would afford extra work for the bright pupil who finds the laboratory pace set by the average pupil too slow. It would give all pupils a chance to work on special problems and to connect the material of the course with their individual outside interests. Starting in this way many teachers could experiment in project-teaching, and by contributing their results, help in extending the scope and perfecting the technique of project-teaching in chemistry.

TEACHING OF THE THEORY OF ELECTROLYTIC DISSOCIATION IN HIGH SCHOOL CHEMISTRY.

By Wm. H. Brown,

Principal of High School, Amherst, Mass.

Belief that a good understanding of the theory of electrolytic dissociation helps the student of chemistry to a better grasp on the subject has led the writer to put considerable time on that topic in his classes. The necessity of a somewhat broad knowledge of chemical reactions for the proper development and appreciation of the theory makes it seem best to postpone its consideration until the course is well advanced, about in the fourteenth week.

I. Remote Preparation.

In the previous study of the course the students have become acquainted with many chemical reactions which are ionic, although no mention of the term has been made. They have observed, however, that there are certain groups of atoms which stay together in reactions, such as the sulphate and hydroxyl groups. Desire for an explanation of this behavior has been aroused in the minds of the students. The electrolytic preparation of hydrogen, oxygen, and chlorine, as well as the action of electrolytic cells of various kinds, also call for an explanation.

II. Direct Preparation.

First Day. The material included in the remote preparation is reviewed. The difference between the conducting powers of solutions of acids, bases, and salts, and of substances such as sugar and gylcerine is demonstrated—the conductivity being measured relatively by the brightness of an electric light bulb connected with the lighting circuit through the solution. The difference between the conductivity of solid and solution is also demonstrated. In the explanation of these phenomena the class has a problem, an insurmountable problem for them if the teacher does not guide them carefully. The problem for the next day is stated, the mechanics of the experiment explained, and new terms such as gram molecule, electrolyte, and non-electrolyte defined.

Second Day. A double period is available for this day, which is devoted to individual laboratory work. The object is to find out the relation between the depression of the freezing point of a solution and its molar concentration, using only non-electrolytes. It must be admitted here that the class can see no connection between this problem and the big problem referred to on the previous day, but in view of the fact that it has taken the greatest scientific minds of the world decades to evolve this theory the high school pupil cannot be expected to march unaided through the logical steps to its statement. The procedure of the experiment is simple. Molar and twice molar solutions of sugar and gylcerine are used, and their freezing points obtained by cooling a test tube containing the solution to the depth of about two inches in a beaker full of a freezing mixture of ice and salt. Supercooling can be prevented by introducing a tiny crystal of ice. The temperature is taken on an ordinary chemical thermometer, the range ordinarily reported by members of the class being from $-1.5°C$ to $-2°C$ for the molar solutions and

from −3°C to −3.5°C for the twice molar solutions. In the few minutes of discussion that follow the laboratory work the results of the class are tabulated on the board. This serves to uncover and eliminate any readings which are far from the median and to furnish averages on which class discussion can be based with some degree of accuracy. When considering the results obtained with one substance the first statement invariably made by the class is that the depression is proportional to the weight dissolved per liter. Calling attention to the results obtained with the other substance shows that this does not hold between two different substances. With a little guidance the class arrives at the statement that the depression is proportional to the number of molecules dissolved per liter or per unit volume.

Third Day. The object of this day's laboratory work is to find out how the depression for molar solutions of sodium chloride and barium chloride (electrolytes) compare with the depression for a molar solution of sugar. The same procedure is followed as on the previous day. The results are usually from −3°C to −3.5°C for the sodium chloride and from −4.5°C to −5°C for the barium chloride. The truth established the day before has apparently been discredited. Again the results are tabulated on the board and it is pointed out that the depression in each case is a multiple of the depression obtained for the molar sugar solution the day before. The work of the day ends at this point and the class is dismissed with instructions to bring in on the next day an explanation of these abnormal depressions. Reference is made to the text.

Fourth Day. The work on freezing points is reviewed, and step by step the supposition is developed that the molecule of a salt when dissolved in water breaks up into two or more particles (which we may call ions) which have the same effect as molecules in the lowering of the freezing point. Assuming that ions carry electric charges, the logic of this supposition can be shown in the case of electrolysis, the electrolytic action of cells, and the non-conductivity of solid sodium chloride and of substances such as sugar (non-electrolytes). The idea is now illustrated by writing of equations showing the ionization of a compound. Attention is called to the reversible character of the reaction. Various equations which have been met previously are now written as ionic equations. The scheme used by Stieglitz, in his "Qualitative Chemical Analysis," is

introduced here and practice is given in the writing of equations in this way.

At some time before leaving the topic the teacher points out that, after all, this is only a theory, a guess, as to what actually takes place, and the objections to the theory should be made known. Some of these are quoted in "Qualitative Chemical Analysis," referred to above, and may also be found in Kahlenberg's "Outlines of Chemistry." The fact is emphasized that, nevertheless, the theory is very generally accepted. Referring to the objections, the teacher points out that it is well to respect the opinions of others, even though we do not accept them, mentioning some of the popularly discredited ideas which have eventually been proven true. The value to progress of unproven theory is pointed out.

III. Later Application.

For several weeks all the equations encountered which are ionic are written as suggested above in order to show the reactions between ions and to make clear the reason for a reaction going to an end. Hydrolysis of salts is also explained in this way. Although it is not considered necessary to write all double decompositions and other ionic reactions in the ionic form, that method is occasionally brought in as a reminder of this great underlying idea. As a result of this emphasis the writer believes that he sees in his pupils a better understanding of chemical phenomena and more power in the working out of equations in new situations.

THE UTILITY OF MINERALOGY IN ELEMENTARY CHEMISTRY.

By J. Norman Taylor,

Washington Preparatory School, Y. M. C. A., Washington, D. C.

There is a realization among teachers of chemistry that the science is best taught from the laboratory standpoint. This is the natural way. One of the primary instincts of the human race is that of curiosity and in satisfying this trait a logical way is opened for the unfoldment of knowledge. Theory, being based on fact, is best assimilated by the utilization of concrete examples and in no other of the sciences is this more evidenced than in chemistry. Interest in chemistry among secondary school students is always awakened by the selection of laboratory experiments of a nature which appeal to the students' every-day

experiences. Growth in the fundamentals of this branch of knowledge and the understanding of its application to every-day affairs is directly proportional to the kind and to the amount of experimental work done in an enthusiastic manner.

Among the first substances which the chemistry student considers is that very abundant and widely distributed one—water. In the consideration of its properties the student observes that through its presence, in certain compounds, hydrates are formed and often crystals are developed. Later, in the study of the metallic compounds, he is aware of the existence of other crystal forms, and in his consideration of the occurrence of the elements in nature, free or combined, he sees that many of them occur in a variety of crystal forms as minerals.

If, in teaching chemistry, the method of presentation is the inductive one, a laboratory period may well be devoted to a study of crystal forms, either at the time when it is considered advisable to discuss water of hydration, or at the time when the occurrence and properties of sulphur are taken up. At any rate, a knowledge of crystalline forms should be introduced in time to enable the student to use it intelligently when the detailed study of the chemical compounds is reached. This knowledge will be of value to the student in studying manufactured chemicals and in familiarizing himself with their appearance, as well as in becoming acquainted with naturally occurring substances, as for example the ores, since descriptions of them often include their crystalline forms and mineralogical names. As crystal forms occur universally, in town and country, and at every season, a brief introduction to crystallography and mineralogy will undoubtedly cause the student to be more observant wherever he may be.

The laboratory work is best conducted by the project method and first of all indicates the types of classification. Inasmuch as Dana's reference books are very largely used in this country, the system of Dana may be followed. By reference to their axes, crystals are classified into six systems, as follows:

The Isometric System.
The Tetragonal System.
The Hexagonal System.
The Orthorhombic System.
The Monoclinic System.
The Triclinic System.

The relation of the axes may be illustrated by means of draw-

ings and if possible, models cut from wood should be used to establish definitely in the minds of the students the relationships of the axes in each system, as well as the relation of crystal forms to each other. If the wooden models are not available, the instructor can cut very serviceable models from cork, or better still, from potatoes.

The classification into systems is impressed upon the consciousness of the student by allowing him to examine the drawings and models and thereby thoroughly acquaint himself with the several systems. If the class is a small one, each individual may be permitted to select several types from among a heterogeneous collection and name each one. That crystal form in certain substances is due to water of hydration may be shown by letting each student examine crystals of blue vitriol ($CuSO_4.5H_2O$), green vitriol ($FeSO_4.7H_2O$), and some of the alums [$M_2(SO_4)_3R_2SO_4.24H_2O$], or other hydrated salts. Upon heating these crystals in a test-tube, he will be led to the conclusion that color and crystal form are destroyed when the water of hydration is driven off.

Finally, the occurrence in nature of the several types may be shown by exhibiting and working with appropriate examples of commonly occurring substances. For example, a cube of salt or galena well illustrates the isometric system, while the hexagonal system is seen in quartz. As nearly every school possesses a mineral collection, there should be no difficulty in obtaining such specimens as will be needful for this purpose. At the same time an incentive will be furnished for the students to collect other minerals and thus aid in the growth of the collection.

This experiment in "live chemistry" is a valuable one in a number of ways. It enlivens the general subject, it stimulates and encourages the faculty of observation, it is a subject of everyday interest, and it makes clear subsequent studies.

IMPORTANT APPOINTMENT FOR A CHICAGO ALUMNUS.

A graduate of the University of Chicago, Dr. Frank Lincoln Stevens, who received his Doctor's degree, *magna cum laude*, from that institution in 1900, has been appointed Bishop Museum Fellow by Yale University and will leave early in May to arrange the mycological collections of the Bishop Museum in Hawaii. Dr. Stevens will also make additional collections of Hawaiian fungi. He is now professor of plant pathology in the University of Illinois and has written a volume on *Diseases of Economic Plants*.

ORGANIZATION OF BIOLOGY AND RELATED SCIENCES IN CITY HIGH SCHOOLS.[1]

By Aleita Hopping,

De Witt Clinton High School, New York City.

During the spring of 1919 two hundred seventy-five questionnaires were sent out to academic high schools in some of the larger cities of the country. The schools were chosen from governmental reports of the Bureau of Education and from other sources. The selection of schools was made so that most of the cities with population over 50,000 were represented.

Probably as a result of the large amount of information requested, only a hundred and ten answers were received, but a wide range of country was covered, the answers coming from thirty-seven different states, and sixty-five different cities.

After the plan of the present work was rather completely thought out, it was found that it duplicated to some extent, a piece of work done several years previously.[2]

A comparative study of the results of 1910, and those obtained in 1919, has therefore been made in the expectation that some indication of the direction of change in organization and condition of biology and other sciences may be found.

The answers to the questionnaires are arranged in five groups according to the states that they represent: The *North Atlantic Division* consisting of Maine (1), New Hampshire (1), Massachusetts (11), Vermont (2), Rhode Island (2), Connecticut (2), New York (4), New Jersey (6), Pennsylvania (9), and Delaware. The *North Central Division*, of Ohio (8), Indiana, Illinois (6), Michigan (3), Wisconsin (3), Minnesota (1), Iowa (2), Missouri (4), Kansas (2), Nebraska (1), S. Dakota, North Dakota (1). The *South Atlantic Division*, of Maryland (1), District of Columbia (1), Virginia (2), West Virginia, North Carolina (1), South Carolina (1), Georgia, Florida (1). The *South Central Division*, of Alabama (1), Mississippi (1), Tennessee, Kentucky, Arkansas (1), Louisiana (1), Texas (2), Oklahoma (1); and the *Western Division*, of New Mexico, Colorado, Wyoming, Montana (2), Idaho, Utah (2), Arizona (1), Nevada, Washington (3), Oregon (1), and California (7). The numbers in parenthesis are the number of answers received from each state. Thirty-eight schools from

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[1]See Patterson's American Educational Directory, Vol. XVII, by Homer L. Patterson, Amer. Educ. Co., Chicago; 1920.

[2]Hunter, G. W. Method, Content and Purpose of Biologic Science in the Secondary Schools of the United States. School Science and Mathematics, 10: 1-10, 103-111; 1910.

Science		N. Atlantic					N. Central					S. Atlantic					S. Central					Western					Total
		1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4		1	2	3	4		
Botany	99	4	9	1	1	6	9	13	2	0	6	0	4	0	0	0	1	1	0	0	1	0	3	1	1	1	64
Zoology	99	0	5	2	1	5	1	9	2	2	3	0	4	0	1	0	1	1	0	0	1	0	3	0	0	1	40
Biology	99	9	8	7	5	5	3	3	1	0	3	0	3	0	1	0	0	2	0	1	0	1	5	0	0	1	58
Hygiene and Human Physiology	99	12	1	2	1	2	16	3	3	2	6	2	0	0	0	0	2	0	0	0	0	1	4	4	1	1	63
General Science	99	23	2	0	0	0	17	1	0	0	0	2	0	0	0	0	3	0	0	0	0	8	0	0	0	1	57
Physiography	99	2	5	2	4	0	6	4	0	1	3	3	0	0	1	1	3	1	0	0	0	6	0	0	1	0	43
Physics	99	0	4	23	5	10	0	0	12	6	2	0	0	3	3	1	0	1	3	2	0	0	0	7	4	0	86
Chemistry	99	0	1	7	23	8	0	1	6	9	5	0	0	3	2	1	0	0	3	2	2	0	0	7	4	1	85
Agriculture	99	2	2	2	2	0	4	3	5	4	5	0	0	0	0	0	0	1	1	1	0	2	1	1	0	0	36
Geology	99	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Astronomy	99	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Psychology	99																										2
Gas Engines	99																										1
Wireless	99																										1
Aeronautics	99																										1
		52	37	46	42	36	56	37	33	24	37	7	11	6	8	3	10	7	7	6	4	18	16	20	11	6	545

TABLE I.

the North Atlantic Division responded, thirty-one from the North Central, seven from the South Atlantic, seven from the South Central and sixteen from the Western, showing a complete total of ninety-nine answers.

Table 1 is a tabulation of the answers from the ninety-nine schools and shows the organization of the Sciences throughout the four years of school work. In this table the answers are classified according to the state from which they come, the division of the country to which they belong being shown in the spaces at the top. To the left, the first column gives the sciences studied. Each of the five columns is divided into five smaller parts, to give the years in which the science is studied, each of these columns being numbered 1, 2, 3, or 4, to indicate that the subject is studied in the 1st, 2nd, 3rd, or 4th year of high school. In some cases, it may be studied in two or more years. In this case the figure is entered in the unnumbered column, meaning that the year is not determined. Since the total number of schools studied is ninety-nine, and thus nearly one hundred, the totals given in the last column on the right may be regarded as percentages. Study of this table shows that about eighty-five per cent. offer physics and chemistry, about sixty-four per cent. offer botany, sixty-three per cent. offer hygiene and human physiology, fifty-eight per cent. offer biology, fifty-seven per cent. offer general science.

Comparing the figures in the first line, it is evident that in every section of the country (except the South Central), botany is given more frequently in the second year than in the first. The same is true of zoology. In the case of biology, the distribution is more even, for in the North Atlantic Division, biology is given as frequently in the first year as in the second, and it is also given in the third and fourth years. In the North Central Division, biology is also given as frequently in the first, as in the second year. In the other divisions, however, biology is given more frequently in the higher years than in the first year. It is to be noticed that in the North Atlantic Division, biology is given more frequently during the last three years than in the first year. This is different from the results obtained in 1910, where biology was given more frequently in the first year in the North Atlantic Division, though more frequently in the second or later years, in the rest of the country.

From the figures given in Figure 1, Table II is constructed. Here the sciences are separated according to years and the percentages of the total given. These results are compared to

the figures for 1910; also, percentage values found for 1910 are compared. These figures seem to show that more of the science work is done in the first year in 1919 than in 1910; the second and third years seem to have changed very little, though the number of courses given in the fourth year appears to have decreased slightly. On the whole, the distribution of sciences in the four years of work appears to be rather even.

TABLE II.
Comparison of Number of Science Courses in the Four Years of School Work.

	1st Year		2nd Year		3rd Year		4th Year		
	No.	%	No.	%	No.	%	No.	%	Total
1910	360	26.2	317	23.1	334	24.3	360	26.2	1371
1919	143	31.5	108	23.8	112	24.6	91	20	454

TABLE III.
Comparison of the Frequency of the Several Sciences in High School Work, in 1910 and 1919.

Yr.	Total	Biological Science		General Science		Physiography		Chemistry		Physics	
		No.	%	No.	%	No.	%	No.	%	No.	%
1910	1371	645	47	9	.7	171	12.4	263	19.1	283	20.6
1919	496	225	45.3	57	11.5	43	8.7	85	17.3	86	17.5

To see if any change is observable in the proportions of the various sciences, Table III is arranged, the figures being taken both for 1910 and 1919. Comparison of these figures shows that in 1910, 47 per cent of the total number of sciences were biological, while 1919, 45.3 per cent were biological, a slight decrease being shown. In 1910, .7 per cent of the total sciences was General Science, whereas in 1919, this has increased to 11.5 per cent. At the same time, physiography, which in 1910 was 12.4 per cent, has dropped to 8.7 per cent. In 1910 and in 1919 chemistry and physics occupy the same importance in the curriculum, with respect to one another. Though the biological sciences show a very slight change, and this is true also of chemistry and physics, the growth of general science appears to be very remarkable, increasing from .7 per cent to 11.5 per cent.

To find if any change in the proportion of the various biological sciences has occurred, the percentage values for 1910

and for 1919 were found. Table IV shows the number of courses in botany, zoology, physiology, and biology recorded among the schools studied in 1910 and also among those studied in 1919. Comparison of these percentage values shows that in every case except biology there has been a decrease in the number of courses given. Whether this change is due to the actual replacement of separate, distinct courses in botany and zoology by a unified course in biology or whether the half-year course in botany and half-year course in zoology have merely been combined and called biology, it is, of course, impossible to say.

TABLE IV.

Percentages of the Biological Sciences in 1910 and in 1919.

	1910		1919		
	Number	Percentage	Number	Percentage	Diff.
Botany	225	35.1	64	28.4	−6.7
Zoology	150	23.4	40	17.8	−5.6
Physiology and Hygiene	193	30.1	63	28.0	−2.1
Biology	73	11.3	58	25.7	+14.4

Taking the figures for 1919 from Table I, the percentages of the total number of botany courses, for example, are found for the first year, second year, third year and fourth year (see Table V). These percentages of the different sciences are compared with similar percentages found for 1910. It is evident that both botany, zoology and biology, are given less frequently in the first year, third year, and fourth year. There is, therefore, a tendency to place these three subjects in the second year of high school. Hygiene and human physiology appear to have increased in the first and third years. Comparing the totals of the biological sciences one finds that there is a decrease in the first and fourth years and a decided increase in the second year, and an inappreciable change in the third year. General science, instead of being entirely in the first year as in 1910, is shifted to some extent to the second year in 1919, although this change is slight. Physics seems to occur more frequently in the third year, but there appears to be no discernible change in the position of chemistry.

Owing to the more or less uncertainty of arrangement of the

Science	First Year			Second Year			Third Year			Fourth Year		
	1910	1919	Diff.	1910	1919	Diff.	1910	1919	Diff.	1910	1919	Diff.
Botany	33.7	28	−5.7	41.7	60	+18.3	11.5	8	−3.5	12.9	4	−8.9
Zoology	18	6.6	−11.4	56	73	+17	16	13	−3	10	6.6	−3.4
Biology	49.3	26	−23.3	31.5	42	+10.5	9.6	16	+6.4	9.6	14	+4.4
Total of Botany, Zoology and Biology	31.0	22.4	−8.6	44	55	+11	13.5	13	−.5	11.5	9	−2.5
Hygiene and Human Physiology	54.4	61	+6.6	17.6	15	−2.6	10.9	16.6	+5.7	17.1	7.4	−9.7
Total Biological Sciences	38	33.8	−4.2	36.6	44.2	+7.6	12.2	13.5	+1.3	13.3	9.8	−3.5
General Science	100	94.6	−5.4	0	5.4	+5.4	0			0		
Physiography	56.6	51.2	−5.4	29	25.6	−3.4	36	5.1	−30.9	10.2	18	+7.8
Physics	0	0	0	9.5	6.8	−2.7	56.3	65.7	+9.4	34.2	27.4	−6.8
Chemistry	0	0	0	3.2	3.0	−.2	37.9	38.2	+.3	58.8	58.8	0

TABLE V.

Comparison of Percentage Value of Sciences by Years in 1910 and in 1919.

various sciences in the high school curriculum, it was thought that perhaps a general expression of opinion on the best sequence of sciences would be of value. This question, therefore, was presented in the words, "What sequence of sciences, by years, would you suggest in organization of high school sciences?" Table VI is the tabulation of the answers to this question. The upper space shows each science, and under each are five columns, the first four for the four years of school; the fifth gives the total number. The body of the table is divided into two parts, the upper for the actual number, the lower for the percentage of the total.

No attempt has been made to find what percentage of the total number of answers offer botany, or zoology or physics, for example, in the curriculum, but rather to find in what year whatever subjects mentioned, should be placed. Evidently it is the opinion here that general science belongs, without question, in the first year, since in every case that general science is mentioned, it is placed in the first year. Botany, zoology and biology are grouped together, for convenience, and it appears that in seventy per cent. of the cases, these subjects are placed in the second year. There does not seem to be any great preference, in chemistry, between the third and fourth year, though the tendency is in favor of the latter. In physics, however, there is a preference of about twenty per cent. in favor of placing physics in the third year. In sixty per cent of the cases, physiography is placed in the first year. Human physiology shows the greatest distribution throughout the four years, though here also, about forty per cent. place it in the first year.

This table becomes more interesting when compared with Table V, which shows how the sciences are actually distributed now, in these schools, in 1919, and the distribution in other schools, in 1910. In the space, "Total of Botany, Zoology and Biology," the percentages for 1910 are compared with these for 1919, and it would appear from these figures that these three sciences are given less frequently in the first year, now than formerly, and are given more frequently in the second year now than heretofore. That there is a tendency for this to continue, is shown by comparing these figures representing the *actual* situation, with these representing the *desired* situation.

If the sciences were arranged as desired, in seventy per cent. of the cases botany, zoology and biology would be placed in the second year, whereas only 44 per cent. were in the second

	General Science					Biology or Botany or Zoology					Chemistry					Physics				
School Year	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Number	55	0	0	0	55	11	55	5	7	78	0	4	35	38	77	0	9	42	27	78
Per Cent	100	0	0	0		14	70	6	9		0	5.2	45.4	49.3		0	11.5	53.8	34.6	

	Physiography					Human Physiography					Agriculture					Psychology				
School Year	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total	1	2	3	4	Total
Number	9	5	1	0	15	11	7	5	4	27		1	1		2				1	1
Per Cent	60	33.3	6.7	0		40.7	25.9	18.5	14.8			50	50						100	

TABLE VI.

Tabulation of Answers to Question, "What Sequence of Sciences by Years, Would You Suggest?"

year, in 1910, and only 55 per cent. are now, at this time (1919) in the second year, among the schools investigated. The situation with respect to chemistry and physics appears to be about as desired since chemistry is placed most frequently in the fourth year and physics in the third. In the case of human physiology, one might conclude that there is a desire to spread the courses in physiology throughout the four years, although it is placed more frequently in the first year than in any other.

A second question asked was, "What is your opinion of the introduction of General Science?" Of the seventy-seven answers to this question, forty-five or 58.4 per cent. consider it good, twenty-four or 31.1 per cent. consider it not good and eight or 10.4 per cent. are doubtful. (See Table VII.) The sentiment in favor of the introduction of General Science is, therefore, not overwhelming.

A third question, "What effect, if any, has the introduction of General or first year science, had upon the position of Biology?" has not shown such exact results, but the answers have been classified to some extent. (Table VIII.) The answers have been separated into three groups. The first group is where the effect has been favorable, and this group is subdivided into three divisions, first, where the interest has been increased, second, the number of students increased, or third, where it has been shifted to the second, third, or fourth year, as a result of the introduction of general science. The second group is where there has been no observable effect. The third group consists of those in which the effect has been unfavorable. This third group is subdivided into three smaller divisions, first, where the actual number of students has decreased; second, where the interest has been decreased; and third, where biology

TABLE VII.

Answers to Question, "What is your Opinion of the Introduction of General Science?"

Good	Not Good	Doubtful	Total
45	24	8	77
58.4%	31.1%	10.4%	

as a separate subject has actually been taken out of the curriculum and replaced by general science. It is interesting to see that roughly about one-third of the answers are unfavorable, one-third favorable, and one-third negative. Where the effect

is negative, it is, perhaps, legitimate to hazard a guess that biology had had its original place in the second, third or fourth year and general science has come into the first year to replace physiography or to share with physiography the place of a first year science and, therefore, there has been no effect upon biology. It is also interesting to note that in about eight per cent. (7.6%) of the cases, as a result of the introduction of general science, biology has actually been annihilated as a high school subject.

TABLE VIII.
"Effect of General Science Upon Biology."

	Favorable			No Effect
Total	Increased Interest	Increased Number of Students	Shifted Biology to 2d, 3d, or 4th Years	Total
24	6	8	10	22
36%	9.1%	12.1%	15.1%	33.3%
	Unfavorable			
Total	Decreased Students	Decreased Interest	Replaced Biology	Final Total
20	11	4	5	66
31%	16.6%	6.1%	7.6%	

Conclusion.

1. Among the more important findings in this piece of work is the very marked tendency toward placing biology in the second or higher school years, in the schools investigated.

2. The bulk of the hygiene work (54% in 1910, 61% in 1919) is done in the first year.

3. General science has increased from .7 per cent. of the total number of science courses in the schools studied in 1910, to 11.5 per cent of the total number of science courses among the schools studied in 1919.

4. Answers to the questionnaire concerning the effect of the introduction of general science upon biology show that about one-third think the effect bad, one-third observe no effect and a little more than one-third consider it favorable.

NOTE ON THE SHAPE OF THE EARTH.

By Wm. O. Beal.

The University of Minnesota, Minneapolis.

In the Question and Answer Department of Current Events, a condensed weekly newspaper widely distributed among public school children, of November 19, 1920, there is the following question and answer:

> "If the earth's rate of rotation were increased, what effect would it have on the length of the day and shape of the earth?" Answer: "The day would be shorter. The shape of the earth would not be changed unless the increase in speed were very great. The tendency would be to increase the diameter at the equator and reduce the polar diameter. If the earth were still in a melted state, and revolving many times faster than it does now, it might finally solidify in a shape more like a wheel than a globe. The fact that the earth is somewhat flattened at the poles indicates that something of the kind occurred while the earth was hot and soft. . . ."

This answer is a curious mixture of truth and improbability. It has been demonstrated in various ways that the whole earth resists deformation when subjected to small forces, like a piece of steel does, and that it returns quickly to its former shape when the force is removed, showing its high degree of rigidity and elasticity. But this in no way demonstrates that the earth would retain its present shape if subjected to a constant large force tending to produce a permanent deformation.

For the sake of illustration consider a cake of ice; it is hard and brittle. But a large sheet of it will flow slowly down a mountain valley, forming a glacier, the central part flowing more rapidly than the margin; the constant large deforming force here being the component of gravity in the direction of the flow.

The volume and mass of the earth are so great, and the deforming forces would be continuous and so large, that if the length of the day were increased or decreased by so much as a minute of time, the shape of the earth would probably be modified to correspond to a new state of equilibrium.

We are not without direct evidence bearing on this conclusion, for Hayford has shown from a thorough discussion of the elaborate geodetic surveys that have been made, that the earth is in an isostatic condition. This means that the mean density of the rock underneath a mountain is less than underneath a trough in the ocean, so that the pressure at the centre of the earth is the same from every direction, and equal to the total weight of the material along any radius of the earth.

BURMA: LAND OF PAGODAS

"Burma is administratively a part of India; geographically it is another country, a smaller triangular pendant hanging down from the necklace of the Himalayas into the Indian Ocean, just to the east of the great Indian triangle. And when the life of the Burmese and their customs are considered, thoughts of India are called to mind chiefly because of striking contrasts," says a bulletin issued from the Washington, D, C., headquarters of the National Geographic Society.

"Though the same can be said for nearly every little-known country, it is especially true of Burma, that there are two; the Burma known to the superficial tourist who visits only the beaten paths like that 'from Rangoon to Mandalay'; and that known to those who live in the country or journey more intimately among its people—the true Burma, little affected by the civilization of the West.

"To the cities have flocked Indians, Chinese, and many Europeans. In Rangoon, a city of 300,000 or more inhabitants, there are more Hindus from India proper than Burmese, and more than half as many Mohammedan Indians. Many shops are in the hands of Armenians. The Burmese of the larger cities, too, have in many ways taken on, at least superficially, the ways of the West. From a visit to the cities, therefore, one can form but guesses of Burma.

Freest Women of the East.

"It is when one reaches the Burmese 'back country' that the suspicions he has gathered in the cities are confirmed and he sees that in many ways Burma is utterly unlike many other Eastern countries. The blighting caste system as such, which he is likely to look upon as the curse of India, is almost wholly lacking. There are members of certain classes, to be sure, who are looked upon as degraded because of their occupations or those of their ancestors—descendants of pagoda slaves, grave diggers and beggars—but the people above them are practically of one level.

"There is none of the veiling of the women as practiced in the Mohammedan countries, none of the seclusion of India, and not even the modified seclusion of China. The women are freer than in most other oriental countries, and may come and go as they please, just as men may, in the houses and temples, on the streets and in the bazaars. Women, in fact, keep shop in many of the bazaar stalls, and are better 'business men' in every way than the Burmese males. The observer from America feels that Burmese women approach much more nearly the freedom of the women in his own country than he was ready to expect.

"There are numerous tribes in Burma, having different customs and speaking different languages, but for the most part they are of the same racial stock. All seem to have a strong element of Mongolian blood. The Burmese are dominant numerically, in influence, and in intelligence. Some of the tribes, of Upper Burma, notably the Chins and Kachins, are quite wild. The Karens, less numerous than the Burmese but numbering almost as many as the Shans, live mostly in the uplands, but since the British occupation have migrated more and more into the lowlands. They are most interesting to Westerners because of the relative ease with which they have been converted to Christianity. Unlike the Burmese they are not Buddhists. Their religion consists chiefly in the propitiating of nature spirits with offerings.

The "Irish of the Orient."

"There is a gaiety and lightness of manner among the Burmese and a love of bright colored clothing and music not found among the more sober and somber Indians, which has earned from the Burmese the title 'Irish of the Orient.' At the same time they are inclined to indolence to a greater

extent than the Indians. But at least there is not the keen economic urge to industry in Burma that there is in India proper. In most parts of Burma the soil is rich, the rainfall plentiful and in some areas more than abundant. The Burmese have long been free from worry over the threat of famine. There is in the country little real poverty, and on the other hand, no great wealth.

"The Burma of the Burmese, that is Lower Burma and the basin of the great Irrawaddy River, is a land of pagodas, the shrines of Buddhism. Thousands upon thousands of these bell-shaped structures surmounted by gilded spires and tinkling bells have been built. Many of them have fallen into decay, but others are built each year. They are the symbols of the hold which the Buddhist religion has upon the people of Burma. It is their belief that the surest way of 'acquiring merit' and achieving holy rest after death is to erect a pagoda; and very few Burmese who are able to add to the country's forest of pagoda spires fail to do so.

"Because the Burmese are a happy rather than a taciturn people, because the social life of the women is not hedged about with artificial barriers, and because their religion insists that they be temperate, refrain from killing animate things and that they give alms, it would seem that this portion of the population could be more easily approached and more easily won over to Christianity than almost any other oriental people. But to Christianize them is no easy task. Missionary work has been carried on among them since the days of Andoniram Judson who first went to Burma in 1814. Although there has been success among the Burmese members of the population it has not been nearly so marked as among the Karens. In the main the Burmese have clung to their religion with great tenacity. They have even borrowed modern western methods in an effort to revivify it. A Young Men's Buddhist Association which seeks to hold the interest of the younger Burmese in the old religion has become active in recent years.

SIZE OF TEXAS—MORE POPULOUS THAN NEW YORK.

"Where Burma touches India proper on the latter's eastern border it is bounded by Bengal and Assam. Farther to the north it touches southeastern Tibet. Along its eastern border, Burma is in contact with China for a considerable distance. The Chinese at one time claimed sovereignty over the land. The lower part of Burma's eastern boundary is formed by French Cochin China and Siam; and to the south and west lies the Bay of Bengal. The total area of Burma is slightly less than that of Texas, while its population is in excess of 12,000,000.

"The greater part of Burma is in the tropics and during half the year much of it is very hot. This heat is especially trying to Europeans in parts of the delta region where the humidity is high. In some sections more than 20 feet of rain falls each year. There is considerable loss of life among natives in some parts of the country from snakes, spiders, poisonous insects and wild animals. Just as India has its Simla to which officials and others journey in the hot season, so Burma has its hill station, Maymyo, only 42 miles from Mandalay, but nearly 2400 feet higher.

"Traveling arrangements in Burma, as in most Eastern countries, are poor. The best facilities are to be found along the Irrawaddy river, the great highway of the country, and along the comparatively few miles of railroad. Even there, however, hotels are seldom available. Throughout most of the country travelers must depend on the British government bungalows, and must carry bedding, and take with them a servant to obtain and prepare their food. Springless bullock carts, bumping over 'roads' that are little more than paths and trails, furnish the principal method of transportation in the interior."

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The first regional meeting of the Western division of this association will be held at the chemical laboratory, Yale University, New Haven, Connecticut, Saturday, May 14, 1921. A most interesting program has been prepared. At 9 o'clock Saturday morning the business meeting will be held at which the general policy of the association will be discussed. Following this, there will be addresses by members of the faculty of Yale University.

Much will be said concerning the operations of the College Entrance Examination Board. Luncheon will be served somewhere on the campus. It behooves every teacher of chemistry in Connecticut at least and many others too, to make provision for attending this most important meeting. Let us get together, chemistry teachers, and extend our acquaintanceship. It will do us all good.

CLASSROOM SAYINGS.

An interior basin is a basin inside the earth.

Revolution is the earth going around the world.

An irregular coast line gives us transportation, commerce, and more education.

Gravity keeps autos, aeroplanes, and people from flying off the earth.

The definite article is omitted with the negative verb if the subject is the direct object of the verb.

The stomach is a sort of catch [cache] for food; it is about ten inches long, four feet wide, and four feet through.

Everybody has four tri-cuspids.

A circle is a line which meets itself, thus forming a closed curve.

Ratio of similitude is when you have a similar polygon.

Sulphuric acid is a strong base.

In the story, he didn't leave the little boy there because the story would have been shorter if he had.

I liked the story because it keeps you in "expence" until the end.

An optimist is a man who examines your eyes.

Animals of Australia have to get about by jumping because of the dense forests, especially the kangaroo.

The following is from a tenth grade scientist:

Adiabatic heating is heat without fire, as a fireless cooker.

MATHEMATICAL INDUCTION ILLUSTRATED.

By Normany Anning.

A simple illustration of both parts of a proof by Mathematical Induction:

1. Place dominoes in a row so that *each*, in falling, will overturn the *next*.
2. Knock over the first.

COMMENTS ARE DESIRED.

Gentlemen:

Will you be kind enough to print the following question in your journal?

"A bird sitting on a perch in a cage is weighed together with the cage. How does this total weight compare with the weight of the same cage but with the bird flying in it? Why?

Perhaps some of your readers will comment on this problem.

Alexander Brodoski.

CHEMISTRY REFERENCES FOR STUDENTS AND TEACHERS[1]

A Booklist Issued by the Chemistry Teachers' Club of New York City.

Committee Members: Earl R. Glenn, The Lincoln School of Teachers College, Columbia University, *Chairman;* F. L. Darrow, Polytechnic Preparatory Country Day School, Brooklyn, N. Y., A. I. Lockhart, Horace Mann School, Teachers' College, Columbia University.

This list is prepared so that a student or teacher may find information upon a specific topic. It is not expected that any library of a high school would have all of these books available, although a large high school might have many of them for reference work. The relative distribution of books by departments is often a matter of dispute among high school teachers. Those who need information upon such matters will be interested to consult a recent article[2] in this journal. The committee wishes to acknowledge the valuable assistance of Miss Anne T. Eaton, who arranged the titles in the present form. We hold ourselves solely responsible for any errors which the list may contain, however, and we shall be glad to be notified in case of discovery. For the most part the titles and prices are recent but new editions are so frequent that information should be obtained direct from the publisher.

Author	*Name of Book*	*Publisher*	*Price*
1. Acids, Alkalies, and Salts.			
Martin, Geoffrey	The salt and alkali industry, 1916	Appleton	$4.00
Smith, Stanley and Milson, F. E.			
Sullivan, T. J.	Sulfuric acid handbook, 1918	McGraw-Hill	2.50
2. Analysis—Qualitative and Quantitative.			
Scott, W. W.	Standard methods of chemical analysis, 1917	Van Nostrand	7.50
Stieglitz, J. O.	Elements of qualitative analysis; 2 Vols., 1911	Century	2.85
3. Biography and Personalities.			
Harrow, Benjamin	Eminent chemists of our time, 1921	Van Nostrand	2.50
Muir, M. M. P.	Heroes of science, chemists	Young	1.00
Roberts, Ethel	Famous chemists, 1911	Macmillan	.75
Tilden, W. A.	Sir William Ramsay, 1918	Macmillan	4.00
Vallery-Radot, Rene	Life of Pasteur	Doubleday	2.50
4. Biological Chemistry.			
Dakin, H. D. and Dunham, E. K.	Antiseptics	Macmillan	1.25
Halliburton	Essentials of chemical physiology, 1920	Longmans	
5. Celluloid and Paper.			
Sindall, R. W.	Manufacture of paper, 1919	Van Nostrand	3.00
Masselon, Roberts, and Cillard	Celluloid, 1921	Lippincott	
Strachan, James	Recovery and remanufacture of waste paper, 1918	Van Nostrand	5.00
6. Cement and Building Materials.			
Brown, W. A.	Portland cement industry	Van Nostrand	
Leighou, R. B.	Chemistry of the materials of the machine and building industries, 1917	McGraw-Hill	3.00
7. Chemistry as a Trade or Profession.			
Gowin, E. B. and Wheatley, W. A.	Occupations, 1916	Ginn & Co.	1.20
Hendrick, Ellwood	Opportunities in chemistry, 1920	Harper	1.00
Newell, F. H. and Drayar, C. E.	Engineering as a career, 1916	Van Nostrand	1.00
Pilcher, R. B.	The profession of chemistry, 1919	Van Nostrand	2.00
8. Colloids.			
Alexander, Jerome	Colloid chemistry, 1919	Van Nostrand	1.00
Bancroft, W. D.	Applied colloid chemistry, 1921	McGraw-Hill	3.00
9. Dyes and Textiles.			
Beacall, Thomas; Challenger, Fred; Martin, Geoffrey; and Sand, H. J. S.	Dyestuffs and coal-tar products, 1915	Appleton	5.00

[1]Reprints of this list may be obtained at cost from the chairman of the committee.

[2]Glenn, Earl R., Past and present practice in high school library book selection from the viewpoint of a science teacher. School Science and Mathematics, Vol. 21, No. 3, 1921.

Brannt, W. T.	Practical dry cleaner, scourer, and garment dyer, 1919	Baird	3.00
Findlay, A.	Treasures of coal-tar, 1918	Van Nostrand	
Ramsey, A. R. J. and Weston, H. C.	Artificial dyestuffs, 1917	Dutton	1.60
	10. Electrochemistry.		
Langbein, George	Electrodeposition of metals, 1920	Baird	7.50
	11. Explosives.		
Barnett, E. du B.	Explosives, matches, and pyrotechnics, 1920	Van Nostrand	5.00
Marshall, John A.	The manufacture and testing of military explosives, 1919	McGraw-Hill	3.00
	12. Fats and Soaps.		
Deite, Carl	Manual of toilet soap making	Van Nostrand	7.50
Lanborn, L. L.	Cottonseed products, 1918	Van Nostrand	4.00
	13. Fermentation Industries.		
Conn, H.W.	Bacteria, yeasts, and molds in the home, Ed. 2, 1917	Ginn & Co.	1.00
Marshall, C. E. and others	Microbiology, 1921	Blakiston	
	14. Foods.		
Bailey, E. H. S.	Source, chemistry, and use of food products, 1917	Blakiston	1.80
Bruce, E. M.	Detection of the common food adulterants	Van Nostrand	1.25
Frandsen, J. H. and Markham, E. A.	The manufacture of ice creams and ices, 1915	Orange-Judd	2.00
Hawk, P. B.	What we eat, 1919	Harper	1.35
Leach, A. E. and Winton, A. L.	Food inspection and analysis, 1913	Wiley	8.50
Olsen, J. C.	Pure foods, 1911	Ginn & Co.	.80
Sherman, H. C.	Chemistry of food and nutrition, 1918	Macmillan	2.10
U. S. Food Administration Collegiate Sect.	Food and the war, 1918	Houghton, Mifflin Co.	.80
Walter, Erich	Manual for the essence industry, 1916	Wiley	4.00
Wiley, H. W.	Beverages and their adulterations, 1913	Blakiston	5.00
	15. Fuels, Gas, Tar, and Coke.		
Brame, J. S. S.	Fuel, solid, liquid and gaseous, 1914	Longmans	5.40
Wagner, F. H.	Coal and coke, 1916	McGraw-Hill	4.00
Wagner, F. H.	Coal gas residuals, 1918	McGraw-Hill	2.50
	16. Glass and Clay Products.		
Ries, Heinrich	Building stones and clay products, 1912	Wiley	3.50
Ries, Heinrich, and Leighton, Henry	History of clay working industry in the U. S., 1909	Wiley	2.50
Rosenhain, Walter	Glass manufacture, 1919	Van Nostrand	4.00
	17. History of Chemistry.		
Alembic Club	Reprints; 14 volumes	Univ. of Chicago Press	.50
Bolton, H. C.	History of the thermometer	Chem. Pub. Co.	1.00
Brown, J. C.	History of chemistry, 1913	Blakiston	3.50
Dana, Edward S.	A century of science in America	Yale Uni. Press	4.00
Hilditch, T. P.	A concise history of chemistry, 1911	Van Nostrand	1.25
Lowry, T. M.	Historical introduction to chemistry, 1917	Macmillan	2.50
Meyer, E. S. C. Von	History of chemistry, 1906	Macmillan	4.25
Moore, F. J.	A history of chemistry, 1918	McGraw-Hill	2.50
Muir, M. M. P.	History of chemical theories and laws, 1907	Wiley	4.00
Muir, M. M.	Story of alchemy, 1903	Appleton	.35
Smith, E. F.	Priestley in America, 1920	Blakiston	1.50
Smith, E. F.	Chemistry in America, 1914	Appleton	2.75
Thorpe, Sir T. E.	History of chemistry; 2 Vol., 1910	Putnam	1.50
Thorpe, Sir T. E.	Essays in historical chemistry, 1902	Macmillan	4.00
Venable, F. P.	A short history of chemistry, 1894	Heath	1.12
	18. High School Laboratory Manuals		
Allyn, L. B.	Elementary applied chemistry, 1912	Ginn & Co.	.60
Blanchard, A. A. and Wade, F. B.	Laboratory manual for foundations of chemistry, 1917	American Bk. Co.	
Black, N. H.	Laboratory experiments in chemistry, 1920	Macmillan	1.20
Brownlee, R. B.; Fuller, R. W., and others	Laboratory exercises to accompany first principles of chemistry, 1917	Allyn and Bacon	.80
Brownlee, R. B.; Fuller, R. W., and others	Experiments in the chemistry of common things, 1915	Allyn and Bacon	.45
Emery, F. B.; Miller, E. W., and Boynton, C. E.	Applied chemistry, 1917	Lyons and Carnahan	1.00
McPherson, William, and Henderson, W. E.	Exercises in chemistry, 1919	Ginn & Co.	.60
Newell, L. C.	Experiments in general chemistry, 1914 (Pt. 2 of his General Chemistry)	Heath	.60
Smith and Mess	Laboratory study of chemistry	Holt	
Williams and Whitman	Laboratory manual of chemistry	Am. Bk. Co.	

19. High School Textbooks.

Blanchard, A. A., and Wade, F. B.	Foundations of chemistry, 1914	American Bk. Co.	1.25
Black, N. H. and Conant, J. B.	Practical chemistry, 1920	Macmillan	
Brownlee, R. B.; Fuller, R. W., and others	Elementary principles of chemistry	Allyn and Bacon	1.60
Brownlee, R. B.; Fuller, R. W., and others	Chemsitry of common things, 1914	Allyn and Bacon	1.50
Cook, C. G.	Practical chemistry for high school students, 1914	Appleton	1.25
Darrow, F. L.	A system of questions and problems in chemistry	Harcourt, B ace & Co.	.80
Dull, C. E.	Essentials of modern chemistry, 1918	Holt	1.40
Emery, F. B.	Elementary chemistry, 1909	Chem. Pub. Co.	1.50
Godfrey, Hollis	Elementary chemistry, 1909	Longmans	1.25
McFarland, B. W.	Practical elementary chemistry, 1915	Scribner	1.25
McPherson, William, and Henderson, W. E.	Elementary study of chemistry, 1917	Ginn & Co.	1.60
Newell, L. C.	General chemistry, 1914	Heath	1.25
Smith, Alexander	Textbook of elementary chemistry, 1914	Century	1.25
Vivian, Alfred	Everyday chemistry, 1920	Am. Bk. Co.	1.64
Weed, H. T.	Chemistry in the home, 1915	Am. Bk. Co.	1.20
Williams, John J.	Vocational chemistry, 1921	Lippincott	1.75

20. Industrial and Engineering Chemistry.

Baskerville, Chas.	Municipal chemistry, 1911	McGraw-Hill	5.00
Bloxam, A. L., and Lewis, S. J.	Chemistry, inorganic and organic	Blakiston	6.00
Dyson, S. S., and Clarkson, S. S.	Chemical works	Van Nostrand	7.50
Henderson, G. G.	Calalysis in industrial chemistry, 1919	Longmans	3.00
Rogers, Allen, and others	Industrial chemistry, a manual for the student and manufacturer, 1920	Van Nostrand	7.50
Thorp, F. H.	Outlines of industrial chemistry, 1916	Macmillan	3.75

21. Inorganic Chemistry.

(A) *Texts.*

Roscoe, Sir H. E., and Schorlemmer, Carl	Treatise on chemistry—	Macmillan	
	Vol. 1, Non-metallic elements		7.50
	Vol. 2, The metals		5.00
Smith, Alexander	Introduction to inorganic chemistry, 1917	Century	2.00

(B) *Labo atory Manuals.*

Baskerville, Charles, and Estabrooke, W. L.	Progressive problems in general chemistry	Heath	1.00
Benedict, F. G.	Chemical lecture experiments, 1901	Macmillan	2.00
Klooster, H. S. Van	Lecture demonstrations in physical chemistry, 1919	Chem. Pub. Co.	2.00
Newth, G. S.	Chemical lecture experiments	Longmans	2.00
Segerblom, Wilhelm	Tables of properties, 1909	Exeter Bk. Pub. Co.	3.00
Smith, Alexander	Experimental inorganic chemistry, 1917	Century	1.00

22. Laboratory Arts, Handbooks, Dictionaries, etc.

Chemical Rubber Co.	Handbook of chemistry and physics	Cleveland, O.	2.00
Frary, F. C.	Laboratory manual of glass blowing, 1914	McGraw-Hill	.75
Kaye, G. W. C., and Laby, T. H.	Tables of physical and chemical constants and some mathematical functions, 1916	Longmans	2.00
Meade, R. K.	Chemist's pocket manual, 1918	Chem. Pub. Co.	4.00
Olsen, J. C., and Melhado, Alfredo	Van Nostrand's chemical annual	Van Nostrand	3.00
Shenstone, W. A.	Methods of glass blowing, 1918	Longmans	1.00
Thorpe, Sir T. E. and others	Dictionary of applied chemistry; 5 Vol.	Longmans	90.00

23. Leather.

Flemming, L. A.	Practical tanning, 1916	Baird	6.00

24. Magazines.

Chemical and metallurgical engineering
Illustrated World
Journal of industrial and engineering chemistry
Scientific American
Scientific American monthly
School science and mathematics 2.50
World's work

25. Metallurgy.

Austin, L. S.	Metallurgy of the common metals, 1921	Wiley	
De Launay, Louis	The world's gold, 1909	Putnam	2.00
Hibbard, H. D.	Manufacture and uses of alloy steels, 1919	Wiley	1.25
Sexton, A. H.	Elementary text book of metallurgy	Lippincott	2.25
Spring, La Verne W.	Non-technical chats on iron and steel, 1917	Stokes	2.50

26. Mineralogy.

Dana, J. D.; Ford, W. E.	Dana's manual of mineralogy, revised and re-written by W. E. Ford, 1912	Wiley	2.50
Spencer, L. J.	The world's minerals, 1916	Stokes	2.75

27. Organic Chemistry.

Cohen, J. B.	Classbook of organic chemistry, 1917	Macmillan	1.75
Haskins, H. D.	Organic chemistry, 1917	Wiley	3.00
Perkin, W. H., and Kipping, F. S.	Organic chemistry, 1917	Lippincott	4.25

28. Paints and Varnishes.

Toch, Maximilian	Chemistry and technology of paints, 1916	Van Nostrand	.50
Sabin, A. H.	Industrial and artistic technology of paints and varnishes, 1916	Wiley	3.50
		Wiley	3.50

29. Petroleum.

Bacon, R. F. and Hamor, W. A.	American petroleum industry, 1916, 2 Vols.	McGraw-Hill	10.00

30. Pharmaceutical.

	Pharmacopeia of the United States. (Cloth.) 1916	Blakiston	3.75
Askinson, G. W.	Perfumes and cosmetics, 1915	Henley	5.00

31. Popular Chemistry.

Auld, S. J. M.	Gas and flame in modern warfare	Doran Co.	1.35
Bashore, H. B.	Sanitation of a country house, 1905	Wiley	1.00
Bird, R. M.	Modern science reader, with special reference to chemistry, 1911	Macmillan	2.00
Cressy, Edward	Discoveries and inventions of the twentieth century, 1914	Dutton	2.50
Cushman, A. S.	Chemistry and civilization, 1920	Richard G. Badger	2.50
Darrow, F. L.	Story of chemistry	Mentor, May 15, '20.	
Duncan, R. K.	The chemistry of commerce, 1907	Harper	2.00
Duncan, R. K.	Some chemical problems of today, 1911	Harper	2.00
Duncan, R. K.	The new knowledge, 1905	Barnes	2.40
Faraday, Michael	Chemical history of the candle, 1903	Harper	1.00
Findlay, Alexander	Chemistry in the service of man, 1917	Longmans	2.00
Gibson, C. R.	Chemistry and its mysteries, 1919	Lippincott	1.50
Glazebrook, R. T.	Science and industry, 1917	Putnam	.50
Hale, Harrison	American chemistry, 1921	Van Nostrand	
Hart-Smith, James	Recent discoveries in inorganic chemistry, 1919	Van Nostrand	1.40
Hendrick, Ellwood	Everyman's chemistry, 1917	Harper	2.00
Hearson, H. R.	Manufacture of iron and steel, 1912	Spon & Chamberlain	1.50
Howe, H. E.	The new stone age, 1921	Century	3.00
Huxley, T. H.	Lay sermons, addresses and reviews. (Pocket classics.) (Lecture on a piece of chalk.)	Macmillan	.40
Koller, Theodor	Utilization of waste products, 1915	Van Nostrand	5.00
Lassar-Cohn	Chemistry in daily life, 1909	Lippincott	1.75
Mannix, J. B.	Mines and their story, 1913	Lippincott	3.75
Martin, A.	Story of a piece of coal	Appleton	.35
Martin, Geoffrey	Triumphs and wonders of modern chemistry, 1912	Van Nostrand	3.00
Martin, Geoffrey	Modern chemistry and its wonders, 1915		3.00
Meade, E. S.	The story of gold, 1908	Appleton	.75
Mouren, Charles	La chemie et la guerre, 1919	Masson & Cie Paris	10 fr.
Patterson, A.M.	A German-English dictionary for chemists, 1917	Wiley	2.00
Patterson, A. M.	A French-English dictionary for chemists, 1921	Wiley	
Philip, J. C.	Achievements of Chemical science, 1913	Macmillan	.60
Philip, J. C.	Romance of modern chemistry, 1909	Lippincott	1.50
Phillips, F. C.	Chemical German	Chem. Pub. Co.	3.50
Pilcher, R. B., and Butler-Jones, Frank	What industry owes to chemical science, 1918	Van Nostrand	1.50
Ramsay, Sir Wm.	Gases of the atmosphere	Macmillan	2.00
Ross, Victor	Evolution of the oil industry, 1920	Doubleday	
Sadtler, S. S.	Chemistry of familiar things, 1916	Lippincott	1.75
Sloane, T. O'C.	Liquid air and the liquefaction of gases, 1920	Henley	3.00
Slosson, E. E.	Creative chemistry, 1919	Century	2.50
Stewart, A. W.	Chemistry and its borderland, 1914	Longmans	1.50
Talbot, F. A.	Oil conquest of the world, 1914	Lippincott	1.50
Tilden, W. A.	Chemical discovery and invention in the twentieth century, 1917	Dutton	3.50
Tower, W. S.	Story of oil, 1909	Appleton	1.10
Unger, M. S. H., Comp.	Review questions and problems in chemistry, 1912	Ginn & Co.	.50
Wood, T. B.	Story of a loaf of bread, 1913	Putnam	1.00

32. Photography.

Derr, Louis	Photography, for students of physics and chemistry, 1916	Macmillan	2.25
Flint, W. R.	Chemistry for photographers, 1920	Amer. Photo. Pub. Co., Boston	
Gamble, Wm.	Photography and its applications, 1920	Pitman	1.00
Verfasser, Julius	The half-tone process	Van Nostrand	3.50

33. Physical Chemistry.

Bigelow, S. L.	Theoretical and physical chemistry, 1912	Century	3.50
Morgan, J. L. R.	The elements of physical chemistry, 1914	Wiley	3.50
Walker, James	Introduction to physical chemistry, 1919	Macmillan	5.75

34. Rubber.

Brown, Harold	Rubber, 1916	Van Nostrand	2.50
Pearson, H. C.	Crude rubber and compounding ingredients, 1918	India Rubber World, 395 B'way, N.Y.	10.00
Porrit, B. D.	Chemistry of rubber, 1914	Van Nostrand	1.00
Terry, H. L.	India rubber and its manufacture, 1919	Van Nostrand	3.50

35. Soils and Fertilizers.

Keitt, T. E.	The chemistry of farm practice, 1917	Wiley	1.50
Lloyd, S. L.	Mining and manufacture of fertilizing materials and their relation to soils, 1918	Van Nostrand	2.00
Lyon, T. L.	Soils and fertilizers, 1917	Macmillan	1.10
Snyder, Harry	Soils and fertilizers, 1909	Macmillan	1.25

36. Subatomic Phenomena and Radioactivity.

Comstock, D. F. and Troland, L. T.	The nature of matter and electricity, 1917	Van Nostrand	2.50
McClung, R. K.	Conduction of electricity through gases, and radio-activity, 1909	Blakiston	2.00
Soddy, Frederick	The interpretation of radium, 1920	Putnam	1.75

37. Sugar, Starch, Gums, and Resins.

Geerligs, H. C. P.	Practical white sugar manufacture, 1915	Van Nostrand	5.00
Harris, F. S.	The sugar-beet in America, 1919	Macmillan	2.25
Parry	Gums and resins	Van Nostrand	

38. Teaching of Chemistry.

Smith, Alexander, and Hall, E. H.	The teaching of chemistry and physics, 1902	Longmans	1.50
Twiss, G. R.	Textbook in the principles of science teaching, 1917	Macmillan	1.40

39. Water, Sewage, and Sanitation

Bailey, E. H. S.	Text book of sanitary and applied chemistry. Ed. 4, 1917	Macmillan	1.60
Kinnicutt, L. F., Winslow, C. E. A., and Pratt, R. W.	Sewage disposal, 1919	Wiley	4.00
Mason, W. P.	Water supply, 1916	Wiley	5.00

40. A Twenty-Five Dollar List

Brownlee, R. B., and others	Chemistry of common things	Allyn and Bacon	1.50
Cressy, Edward	Discoveries and inventions of the twentieth century, 1914	Dutton	2.50
Chemical Rubber Co.	Handbook of chemistry and physics		2.00
Duncan, R. K.	Chemistry of commerce, 1907	Harper	2.00
	Some chemical problems of today, 1914	Harper	2.00
Hendrick, Ellwood	Everyman's chemistry, 1917	Harper	2.00
Harrow, Benjamin	Eminent chemists of our times, 1921	Van Nostrand	2.50
Moore, F. J.	A history of chemistry, 1918	McGraw-Hill	2.50
Pilcher, R. B.	The profession of chemistry, 1919	Van Nostrand	2.00
Slosson, E. E.	Creative chemistry, 1919	Century	2.50
Smith, Alexander	Introduction to inorganic chemistry, 1917	Harper	2.00
Thorp, F. H.	Outlines of industrial chemistry, 1917	Century	2.60

41. A Fifty Dollar List

(In addition to the books listed under the twenty-five dollar list the following should be added.)

Author	*Name of Book*	*Publisher*	*Price*
Alexander, Jerome	Colloid Chemistry, 1919	Van Nostrand	1.00
Cushman, A. S.	Chemistry and civilization, 1920	Badger	2.50
Comstock, D. F. and Troland, L. T.	The nature of matter and electricity, 1917	Van Nostrand	2.50
Findlay, Alexander	Chemistry in the service of man, 1917	Longmans	2.00
Howe, H. E.	The new stone age, 1921	Century	3.00
Rogers, Allen and others	Industrial chemistry, 1920	Van Nostrand	7.50
Sloane, T. O C.	Liquid air, 1920	Henley	2.50
Spencer, L. J.	The world's minerals, 1916	Stokes	2.75
Tilden, W. A.	Chemical discovery and invention in the twentieth century, 1917	Dutton	3.50

42. Addresses of Publishers.

Allyn and Bacon, 50 Bacon St., Boston.
American Book Co., 100 Washington Square, New York.
D. Appleton and Co., 29 West 32 St., New York.
A. S. Barnes and Co., 30 Irving Place, New York.
P. Blackiston's Son and Co., 1012 Walnut St., Philadelphia.
H. C. Baird Co., 2 West 45 Street, New York.
Bruce Publishing Co., 354 Milwaukee St., Milwaukee, Wis.
R. G. Badger, 194 Boylston St., Boston.
Century Co., 353 Fourth Ave., New York.
Chemical Pub. Co., Easton, Pa.
E. P. Dutton and Co., 681 Fifth Ave., New York.
G. H. Doran Co., 244 Madison Ave., New York.
Doubleday, Page and Co., Garden City, New York.
Charles Griffin and Co., London, England (See J. P. Lippincott Co.).
Ginn and Co., 15 Ashburton Place, Boston.
Harper and Brothers, Franklin Square, New York.
D. C. Heath and Co., 50 Beacon Street, Boston.
Houghton, Mifflin Co., 4 Park Place, Boston.
Henry Holt and Co., 19 West 44 Street, New York.
N. W. Henley Pub. Co., 2 West 45 Street, New York.
J. P. Lippincott Co., Washington Square, Philadelphia
Longmans, Green and Co., 443 Fourth Ave., New York.
Lyons and Carnahan, 623 S. Wabash Ave., Chicago.
Mentor, 114 East 16 Street, New York.
Macmillan Co., 66 Fifth Ave., New York.
McGraw-Hill Book Co., 239 West 39 Street, New York.
Munn and Co., 233 Broadway, New York.
Orange-Judd Co., 315 Fourth Ave., New York.
Isaac Pitman and Sons, 2 West 45 Street, New York.
G. P. Putnam's Sons, 2 West 45 Street, New York.
F. A. Stokes Co., 443 Fourth Ave., New York.
Charles Scribner's Sons, 597 Fifth Ave., New York.
Spon and Chamberlain, 120 Liberty Street, New York.
D. Van Nostrand Co., 8 Warren St., New York.
John Wiley and Sons, 432 Fourth Ave., New York.

43. Appendix for New Books.

WOULD AID AMERICAN FARMER COMPETE IN WORLD MARKETS.

As a means for aiding the American farmer to compete in the markets of the world the Secretary of Agriculture in his annual report to the President urged that definite provision be made for the systematic collection and dissemination of statistics regarding the production and supply of and the demand for agricultural products in foreign countries.

The foreign markets division of the Bureau of Markets, he said, is keeping in as close touch as possible with conditions abroad, but it has neither the personnel nor the facilities for meeting the demands made upon it. "It is highly essential that definite provision be made for the building up of this branch of the department's work, in order that it may be in position to render effective service to producers, farm organizations, and others," he said. "Since May, 1918, an agricultural trade commissioner has been stationed in the united kingdom to study the markets for agricultural products in Europe and to make timely reports for the information of American producers and exporters. The work of this commissioner has conclusively demonstrated the desirability of stationing additional commissioners at strategic points in the various markets of the world. Plans also have been developed for the establishment of an office in Buenos Aires to aid in promoting our trade with South America in purebred live stock," said the report.

PROBLEM DEPARTMENT.

Conducted by Jos. A. Nyberg.
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1044 E. Marquette Road, Chicago.

LATE SOLUTIONS.

676, 678. *Walter R. Warne, Pennsylvania State College, State College, Pennsylvania.*

679. *Smith Turner, student, Parkersburg H. S., West Virginia.*

683, 684, 685. *Morris Monsky, Brooklyn Boys' High School Mathematics Club.*

SOLUTION OF PROBLEMS.

684. *Proposed by F. A. Cadwell, St. Paul, Minn.*

Construct a triangle, having given the base c, $\angle$B (greater than $\angle$A) and d = AC—BC.

This problem was solved last month by the usual method of the text books finding the point C first, and also by a second method which found the unknown $\angle$A first. The following solution is of interest as it shows how to find the side b first. To finish the problem completely, we ought to devise a method for finding the $\angle$C first, or the side a.

Solution by DeWitt T. Weaver, Sistersville H. S., West Virginia.

On the line c, or AB, construct $\angle ABD = \angle B$, and let l be the projection of c on the line AD. Then $b^2 = a^2+c^2-2al$. Replace a by $b-d$, and solve for b. $b = (c^2+2ld+d^2)/(2d+2l)$. Since c, d, l are known, b can be determined.

[It would be an interesting problem to show that the construction of this fraction for b can be accomplished by the solution given last month for the triangle.—*Editor.*]

686. *Proposed by Norman Anning, Ann Arbor, Mich.*

Construct the acute angle whose sine is equal to its cotangent.

I. *Solution by Lois C. Ketcham, Chester Agricultural H. S., Chester, Virginia.*

If sinA, in $\triangle$ABC, is to equal cotA, then $a/c = b/a$. Also $a^2+b^2 = c^2$.

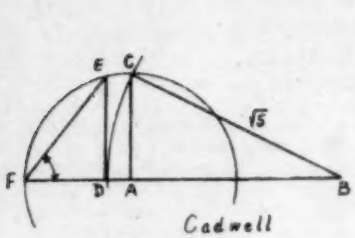
Solving these two equations gives $b/c = (-1+\sqrt{5})/2$, and the problem is to construct a right angle knowing the ratio of the sides.

II. *Solution by Henry Wood, Corinth, New York.*

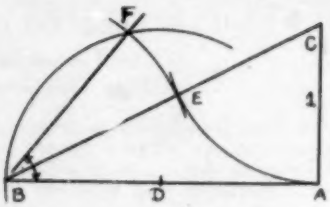
If sinA = cotA, then $\cos^2A+\cos A-1 = 0$, or $\cos A = (-1+\sqrt{5})/2$.

Also solved by N. Barotz, New York City; F. A. Cadwell, St. Paul, Minn.; T. E. N. Eaton, Redlands H. S., Cal.; C. E. Githens, Wheeling, W. Va.; Michael Goldberg, Philadelphia, Pa.; H. E. A. Lazott, Nashua, N. H.; Fred A. Lewis, University, Ala.; A. MacNeish, Chicago; DeWitt Weaver; and the following students: *Moe Buchman,* and *Morris Monsky, Brooklyn, N. Y.; Nicholas Kefalaias, Hillsdale College, Mich.; Alma M. Ketterer,* and *Chas. Landshof, Dickinson H. S., Jersey City; Gabriel Rousseau, Ecole Polytechnique, Montreal; Smith Turner, Parkersburg, W. Va.;* and by the *class in geometry, Notre Dame Ladies' College, Montreal, Canada.*

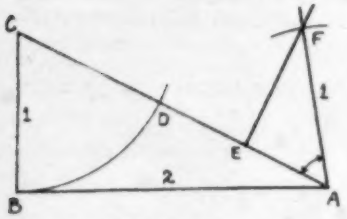
Of the various constructions received four are shown in the figures. A description of the figures is hardly necessary since the order of the letters, A, B, C, etc., gives the order in which the points were found. Teachers may find it of interest to assign as an exercise the computation of the various lines in each figure. The given problem may also be stated for a gemoetry class as: Find the right triangle for which one side is a mean proportional between the other side and the hypotenuse.



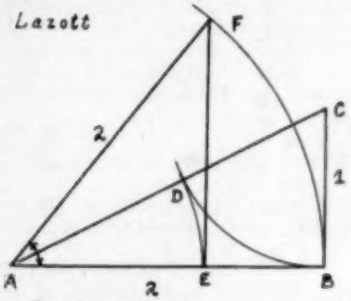
Cadwell



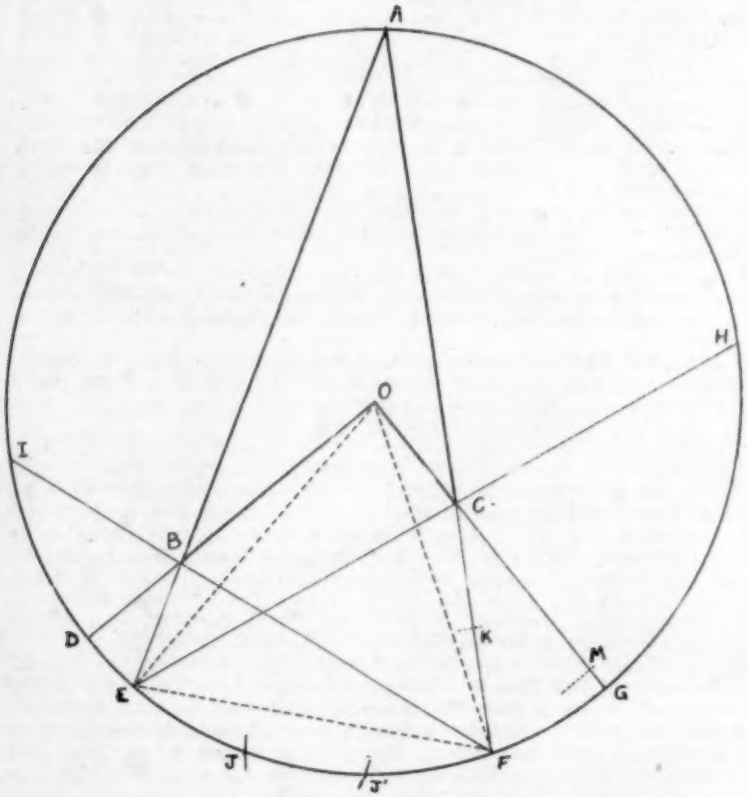
Lazott



Githens



Rousseau



687. *Proposed by F. A. Cadwell, St. Paul, Minn.*

ABOC is a quadrilateral, each of the angles at A, B, and C, being 30°. A circle is drawn with O as center and OA as radius. AB, AC, and OC are produced and intersect the circle at E, F, and G, respectively. The line from F to B intersects the circle at I, and the line from E to C intersects the circle at H. Prove that arc FG equals one-fourth the arc FH, and that arc IH is 180°.

Solution by the Senior Class in Geometry, Notre Dame Ladies College, Montreal, Canada.

Draw OE, EF, FO. Since $\angle A = 30°$, arc EF will equal 60° and the $\triangle OEF$ is equilateral. Draw $EK \perp FC$, and $FM \perp CG$. Then $\triangle EFK = \triangle OFM$ because $EF = OF$ and $\angle EFK = \angle OFM$ since each equals $60° + \angle OFC$. Hence $FM = FK$. But in $\triangle CFM$, $FM = FC/2$, and so $FK = KC$. Hence $\angle HEF = 2\angle FEK = 2 \cdot \angle FOG$. Since $\angle HEF$ is an inscribed angle, and $\angle FOG$ is a central angle, we have $\text{arc}FH = 4 \cdot \text{arc}FG$.

By drawing perpendiculars from F to EB, and from E to OB, we can similarly prove $\text{arc}EI = 4 \cdot \text{arc}ED$.

Since $\angle BOC = 90°$, and $\angle EOF = 60°$, it follows that $\text{arc}ED + \text{arc}FG = 30°$; and then from what we have proved $\text{arc}EI + \text{arc}FH = 120°$. Adding to this the 60° arc EF, we find that $\text{arc}IH = 180°$.

Similarly proved by Gabriel Rousseau.

The proof by the *proposer* is slightly different but is interesting because it shows how much we can overlook in a picture. If we select the point J so that FJ = FC, and draw the necessary lines, the triangles OBE, EJF, and FCO will be equal, and they lie one on each side of the equilateral $\triangle OEF$. Also $\triangle BEF = \triangle EOJ = \triangle EOC$, and $\triangle OJF = \triangle EFC = \triangle BOF$, and OD bisects $\angle IOJ$, and OG bisects $\angle JOH$. If, for the sake of symmetry, we make $EJ' = CF$, then we find $\triangle EOJ' = \triangle EFC$, $\triangle OJ'F = \triangle BEF$, $\text{arc}J'H = 2\ \text{arc}J'D$, $\text{arc}IJ' = 2 \cdot \text{arc}J'G$. And there may be still more relations.

688. *Proposed by E. Kesner, Salida, Col.*

Two baseball teams, presumably of equal merit, are playing a series of games with the understanding that the first team winning four games wins the series. They have played two games, both won by A. What are the odds in favor of A's winning the series?

I. *Solution by H. E. A. Lazott, Nashua, New Hampshire.*

It is evident that A has 2 more games to win while B has 4, and excluding the possibility of tie games, at most 5 games only will be necessary. Tie-games need not be considered since they neither affect the existing standing nor change the number of games remaining to be played. As the probability of either winning is equal, $p = q = 1/2$. Then if we let $r = 2$, the games A must win, and $n = 5$ the greatest number of decisive games to be played, the conditions are those of Pascal's probability problem solved by the formula

$${}_nC_r p^r q^{n-r} + {}_nC_{r+1} p^{r+1} q^{n-r+1} + \cdots\cdots {}_nC_{n-1} p^{n-1} q + p^n$$

which for this case becomes

$$10/32 + 10/32 + 5/32 + 1/32 = 13/16.$$

Since the probability of A's winning is 13/16, the odds in favor of A are 13 to 3. Bernoulli's formula ($n = 2$, $m = 4$, $p = q = 1/2$) gives the same result.

II. *Solution by A. M. Waas, Philadelphia, Pennsylvania.*

There are 2^5 or 32 ways in which the remaining games may be played. B may win all five, or, select four of the 5 which can be done in $5 \times 4 \times 3 \times 2 \div 4! = 5$ ways. Therefore the number of ways that B can win is $1 + 5$ or 6 ways; A can then win in $32 - 6$ or 26 ways. Hence the odds are 13 to 3 in favor of A.

Similarly solved by Morris Monsky.

III. *Solution by N. Barotz, New York City.*

If we number the games to be played 1, 2, 3, 4, 5, then B wins if he wins the games (1, 2, 3, 4) or (2, 3, 4, 5) or (1, 3, 4, 5) or (1, 2, 4, 5) or (1, 2, 3, 5). A wins the series if he wins the games (1, 2), (1, 3), (1, 4), (1, 5), (2, 3) (2, 4), (2, 5), (3, 4), (3, 5), (4, 5). Hence B may win in 5 ways (${}_5C_4$), and A in 10 ways (${}_5C_3$). The odds are 2 to 1 in favor of A.

The Editor believes the second solution is wrong because among the 32 ways of playing are counted those in which the order of winning is, for example, AABBA, AABAB, AABBB etc., and even AAAAA has been counted. But all these ways in which A wins the first two should be counted only once instead of 8 ways. Similarly other games have been counted too often. The same error arises in the first solution.

689. *An old puzzle.*

How high is it safe to build a pyramid of eggs, if each egg weighs two ounces and would sustain a pressure of eight pounds?

Solution by H. E. A. Lazott.

Since eight pounds is to two ounces as 64 : 1 the bottom layer of eggs can support 64 times as many eggs as it itself numbers. Hence considering the bottom as the $(n+1)$th layer, we must find the sum of the eggs in the n layers above it and equate the ratio to 64.

For a triangle pyramid we have

$[1, +1+2, +1+2+3, \cdots, +1+2+3 \cdots +n]/[1+2+3+\cdots n+1] = 64$ or $[n(n+1)(n+2)/6]/[(n+1)(n+2)/6] = 64$ or $n = 192$.

For a square pyramid we have $(1+4+9 \cdots +n^2)/(n+1)^2 = 64$ or $n(n+1)(2n+1)/6(n+1)^2 = 64$ or $2n^2-383n-384 = 0$, or $n = 192.5$ (approx.)

Also solved by Michael Goldberg.

690. *For Undergraduates. Proposed by Moe Buchman, Brooklyn Boys' High School Mathematics Club.*

A train going at a certain rate meets with an accident which delays it a hours. After the accident the train's rate is one nth less than its original rate, and it reaches its destination b hours late. If the accident had occurred a distance c miles farther away, the train would have been d hours late. What was the train's original rate?

Solution by W. P. DeJarnette, Lanier High School, Montgomery, Alabama.

Let x = rate of train, y = no. miles before accident, and z = no. miles after accident. Then

$y+c$ = no. of miles before 2nd accident,
$z-c$ = no. of miles after 2nd accident,
$x-x/n$ = rate for z miles, 1st trip,
and $x-x/n$ = rate for $z-c$ miles, 2nd trip.
$\therefore$ y/x = no. of hrs. to go y miles,
$z(x-x/n)$ = no. of hrs. to go z miles,
$(y+c)/n$ = no. of hrs. to go $y+c$ miles,
and $(z-c)/(x-x/n)$ = no. of hrs. to go $z-c$ miles,
$\therefore$ $y/x+z/(x-x/n)+a$ = no. of hrs. to make 1st trip, and
$(y+c)/x+(z-c)/(x-x/n)+a$ = no. of hrs. to make 2nd trip.
$\because$ b = no hrs. late 1st trip, and d = no. hrs. late 2nd trip
$\therefore$ $b-d = [y/x+z/(x-x/n)\}-[(y+c)/x+(z-c)/(x-x/n)]$
$= -c/x+c/(x-x/n) = -c/x+cn/x(n-1)$.
$\therefore$ $x(b-d)(n-1) = -c(n-1)+cn$
$x = c/(b-d)(n-1)$.

This is such a concise, orderly solution that it is printed exactly as received. The next best solution was by *Dean B. Parker, Northeast High School, Kansas City, Mo.*, whose steps were less logical but he avoided the use of so many letters by calling $y+c$ the number of miles from the first accident to the destination. The third best was *Engle Randolph, Redlands H. S., California.* Also solved by *Dorothy Eaton, Redlands H. S.; Chas. Landshof, Dickinson H. S., Jersey City; Morris Monsky, Brooklyn, N. Y.; Irene Ricard, Notre Dame Ladies College, Montreal; Forrest Young, Redlands H. S.*, and the *Proposer.*

The reader will be interested in finding the error in the following solution. Let A and D be the ends of the line, B the point of the first wreck and C the point of the second, so that BC = c. Now the distance AB was evidently covered at the same rates and hence in the same time in both cases; similarly the distance CD was covered at the same reduced

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GOVERNMENT MAP OF OIL AND GAS FIELDS OF KANSAS.

The United States Geological Survey, Department of the Interior, has just published a map of the oil and gas fields of Kansas. This map, which is on a scale of twelve miles to the inch, shows not only economic data of special interest to the oil man, but the township net, county boundaries, railroads, drainage lines and principal towns and cities. The oil fields are outlined in green and the gas fields in red, scattered occurrences of oil or of gas that are not of sufficient importance to be classified as fields are plainly indicated, the pipe lines are shown in a distinctive color, the locations of refineries are indicated, and the names of the principal fields are given.

This map, which should be of extraordinary value to producers, refiners, and geologists interested in the Kansas fields, was compiled under the direction of G. B. Richardson of the United States Geological Survey, and was made possible by the cooperation of many of the producing companies and geologists whose interests lie in Kansas. The map is sold for fifty cents a copy and may be obtained from the Director of the United States Geological Survey, Washington, D. C.

THE NOME GOLD FIELDS.

The famous Nome placer gold fields discovered in 1898 have now produced gold worth nearly eighty million dollars. Much of the gold mined in this region is won by the use of dredges. Twenty-two of these machines were in operation in 1919 and made a total gold output of $450,000, and open-cut and deep mining in that year brought the value of the total gold output of Nome and other districts of the Seward Peninsula up to $1,360,000. In addition to the gold, about 56 tons of placer tin and 20 ounces of platinum were produced on Seward Peninsula in 1919. These operations are briefly described in a report entitled, "Mining on Seward Peninsula, Alaska" (Bulletin 714-F), by George L. Harrington, just issued by the U. S. Geological Survey, Department of the Interior.

rate in both cases. Hence the difference in *time* ($b-d$) can only be due to the difference in *rates* over the *distance* BC or c miles. This difference in rates is x/n. Consequently $b-d = c/(x/n)$ or $x = cn/(b-d)$.

PROBLEMS FOR SOLUTION.

701. *Proposed by Arthur H. Lord, Classical High School, Lynn, Mass.*

AOB is a right angle and arc ACDB its quadrant trisected at the points C and D. P is a point on the bisector of the reflex $\angle BOA$. Prove that CP and DP do *not* trisect $\angle APB$.

702. *Proposed by James Smith, Brooklyn, New York.*

Find to how many decimals the following approximate construction for $\sqrt[3]{2}$ is correct: ABC is a right angle with BA = 1/2, and BC = 1. E is the mid-point of BC, and F is a point such that EBAF is a square. On CF construct outward an equilateral $\triangle CFG$ ($\angle BCG = 105°$). D is the mid-point of BA. Then DG = $\sqrt[3]{2}$ approximately.

703. *Proposed by L. E. Lunn, Heron Lake, Minnesota.*

A man bought a cow which each year for twenty years thereafter gave birth to a heifer calf. Each of the calves, at the end of two years gave birth to a heifer calf, and continued thereafter with all the descendants in this same ratio. How many head of cattle were there originating from the one cow at the end of twenty years?

704. *Proposed by I. N. Warner, State Normal School, Platteville, Wis.*

Find integral values of x and k which will satisfy the equation $129x = 133k+3920$. This equation arises from the problem: A dealer bought eggs at such prices that he averaged paying 19c for 7 eggs; 8 eggs were lost, and the remainder sold at an average of 70c for every 19 eggs. Find the number of eggs if k was the profit. Another similar problem is the following from *Glashan's Arithmetic:* A dealer bought some eggs at the rate of 11 for 9c, lost 3 eggs, and sold the rest at 9 for 11c, gaining $2.63. Here the equation is $40x = 99k+363$. What other value besides $k = 263$ will give an integral value of x? More generally stated the problem is this: Is there any relation which can be used to make problems of the above types such as the relations, for example, that we have in making triangles with integral sides and satisfying certain other conditions.

705. *For undergraduates. Proposed by the Editor.*

ABCD is a rectangular garden, AB = 60, and AD = 40. E is a point on AD, and F a point on CB such that AE = CF. The parallelogram AFCE is the walk, three feet wide, going through the garden. Find the area of the walk.

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Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.* **Ask for the examinations you would especially like to get.**

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Please send also the addresses of book sellers or examination boards from whom such questions might be obtained.

The contribution of Mr. John Lundberg, of Göteborg, Sweden, has already been acknowledged.

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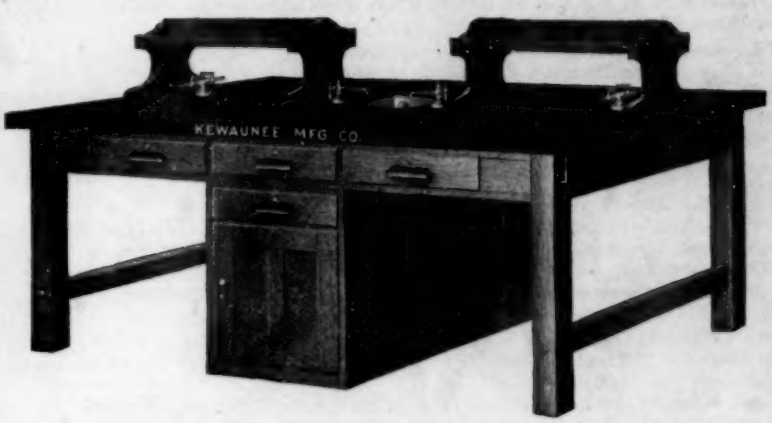

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Questions and Problems for Solution.

355. *The motorcycle problem published in January, 1921, is a "sticker."* What assumptions must be made?

369. *Adapted from Sea Power, March, 1921:*

"Now it takes twenty-eight seconds for a bomb to drop from a height of 12,000 feet; and during twenty-eight seconds a 22-knot capital ship can move 1,022 feet in avoiding a bomb dropped from above."

Test the truth of these statements. How are they figured?

In the case of the falling bomb, what allowance if any was made for resistance of the air?

370. *From an examination paper of Cambridge University:*

A ship A was 20 miles due north of another ship B at noon. A was sailing due south at the rate of 12 miles per hour, B due east at 9 miles per hour. At what time were they nearest each other: and how far apart were they then?

Tests.

371. *Test M6—Power.*

Please time yourself on this test and send in your time to the editor of this department.

Other tests were published in February, March, and April, 1921.

Try them on a class and send in your results. They will be interesting.

TEST M6—POWER.

1. What is the rate of doing work when a horse walking 2 1-2 miles per hour (or 220 feet per minute) can just lift by a rope led over a pulley a weight of 150 pounds? Ans.———

2. What is the horse power of a pump that will lift 30,000 cubic feet of water (1 cu. ft. water weighs 62.4 lb.) every hour from a mine 165 feet deep? Ans.———

3. What horse power can be obtained from a waterfall 60 feet high in a stream whose average width is 30 feet and depth is 6 feet moving 4 feet per second? (1 cu. ft. water weighs 62.4 lb.) Ans.———

No.———. Attempts———. Right———. Wrong———.

Examination Papers.

Province of Alberta.

High School and Matriculation Examinations Board, Departmental Examinations, 1920.

(In continuation of other papers published in February, March, and April, 1921.)

372.

GRADE X—PHYSICAL SCIENCE.

Time—Two and one-half hours.

Values		
4	**1.**	(*a*) State and explain the Principle of the Conservation of Energy.
3		(*b*) By reference to an example show that energy may be transformed from one form to another.
4	**2.**	(*a*) Show by reference to examples that a machine may be used (1) to change the direction in which a force acts, (2) to gain mechanical advantage.
4		(*b*) What weight may be raised by a lever of the first class, the length of which is 30 inches, if the fulcrum is placed 6 inches from one end of the lever and a force of 25 pounds is applied at the other end?
2	**3.**	(*a*) State Pascal's Principle.
6		(*b*) Describe, giving diagram, the construction and operation of the hydraulic press.
4		(*c*) Explain why a very great pressure may be obtained by this press through the exertion of a small force.
4	**4.**	(*a*) How may the specific gravity of a piece of cork be determined experimentally?

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3 (*b*) If the volume of a floating body is 60 ccm. and its specific gravity is 0.75, how many grams of water will it displace when floating?

4 (*c*) Show by means of an experiment that air exerts a buoyant force.

2 **5.** (*a*) Distinguish between temperature and quantity of heat.

8 (*b*) How may the fixed points on a thermometer be obtained?

4 (*c*) Find the Fahrenheit readings corresponding to the following Centigrade readings: 30° C., −10° C.

6 **6.** (*a*) How may the heat of fusion of ice be determined experimentally?

6 (*b*) A thermometer is inserted in a vessel containing ice at −10°C. Heat is applied until the ice is melted and the water formed is changed to steam. During which periods does the temperature (1) remain stationary, (2) change? Why?

5 (*c*) What quantity of heat will be required to change 60 grams of ice at −10°C. to water at 40°C. if the specific heat of ice is 0.5?

4 **7.** (*a*) Describe an experiment to illustrate the transference of heat by convection.

4 (*b*) Describe a practical application of convection as a mode of heat transference.

2 (*c*) Give one important respect in which convection differs from conduction.

6 **8.** (*a*) Define or write explanatory notes on polarity, magnetic inclination and magnetic induction.

6 (*b*) Describe the construction and action of any appliance in which an electromagnet forms an essential part.

9. Select any *three* of the following questions:

3 (*a*) Why may the metal top of a sealer be readily removed when it has been immersed for a short time in warm water?

3 (*b*) Why does the presence of a large body of water produce a moderating effect on climate?

3 (*c*) Why is a thermometer constructed with a comparatively large bulb and a tube of capillary bore?

3 (*d*) Why is ink absorbed more readily by blotting paper than by writing paper?

3 (*e*) Why do the iron frames of school desks become magnets?

3 (*f*) When a pail of liquid lard solidifies, why is the surface depressed?

100

Grade XI—Agriculture.

373.

Time—Two and one-half hours.

Values.

4 **1.** (*a*) Divide soils into two classes according to formation and give an example of each class.

9 (*b*) Write concise notes on sand, clay and humus under the following heads: (1) Origin, (2) composition, (3) chief agencies contributing to their formation.

5 **2.** (*a*) Describe an experiment to show the comparative rates at which water percolates through clay, sand, and humus.

6 (*b*) By description of an experiment illustrate the comparative power of sand, clay and humus to conduct water by capillarity.

3 (*c*) Upon what properties of a soil does its moisture-holding capacity depend?

3 **3.** (*a*) Describe the method of showing the importance of root hairs to a plant.

5 (*b*) By description of an experiment illustrate the principle

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involved in the absorption of food material by the roots of plants.

4 (*c*) State important changes which take place in the leaves of plants and the conditions necessary to such changes.

3 **4.** (*a*) How is the available amount of plant food in the soil affected by soil texture?

(*b*) Compounds of nitrogen, phosphorus and potassium are important plant foods.

6 (1) From what sources does the soil obtain these compounds?

6 (2) Show how the farmer supplements the supply of any two of these in the soil.

5. In the spring of 1919, following the dry season of 1918, observations were made on the depths to which moisture had penetrated soil under different conditions after a heavy snowfall as follows: on unbroken prairie 4 inches, on stubble land 8 inches, on summer-fallow 16 inches.

4 (*a*) Of what value to the farmer is this information from the points of view of moisture supply and farm practice?

3 (*b*) What should be done to conserve the moisture of the summer-fallow for the season's crop?

8 (*c*) What are the objects in view in disking land immediately after a crop is cut from it?

9 **6.** Describe experiments to show how you would test a sample of wheat for (1) purity, (2) vitality, (3) strength of germination.

4 **7.** (*a*) State the conditions of soil which affect its temperature.

2 (*b*) Give two reasons why lack of surface drainage lowers the temperature of soil.

9 **8.** (*a*) Classify soil bacteria, giving a brief account of the changes brought about by each class.

4 (*b*) What are the soil conditions suitable for the development of beneficial soil bacteria?

2 **9.** (*a*) Name two fungus diseases which are injurious to grain crops in Alberta and describe a method of combating one of them.

6 (*b*) By what practical means may the farmer, to a considerable extent, control the ravages of insect pests?

10 (*c*) "Birds are the allies of the Agriculturist." Discuss this statement with special reference to at least five of our native birds.

10. Write full notes on any *three* of the following:

4 (*a*) The relation of the feeding of animals on the farm to the upkeep of the soil.

4 (*b*) The advantage of marketing what grows on the farm in the form of stock or stock products instead of in the form of grain or hay.

4 (*c*) The reasons for the condition of the market in Alberta for (1) light, (2) heavy horses.

4 (*d*) The advantages and disadvantages of bee-keeping in Alberta.

4 (*e*) The value of ensilage as a food for stock in Alberta and what plants should be used for it.

125

Solutions and Answers.

355. The motorcycle problem published in January, 1921, remains unsolved. Certain assumptions must be made. What are they?

349. *From an examination of the Scottish Universities Examination Board.*

The measure of an acceleration when the units of space and time are a foot and a second is 3. What would be the measure of the same acceleration when the units are a yard and a minute?

A body starting from rest, and moving with uniform acceleration, describes 16 1-4 ft. in the seventh second of its motion: find the acceleration.

Solution:

The dimensions for acceleration are $[L]/[T]^2$. Then, on changing an

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acceleration from *feet per sec.* per sec. to *yards per minute* per minute, the dimensions become

$$[(\text{feet} \div 3) = \text{yards}]/[(\text{sec.} \div 60) = \text{min.}]^2$$

and

3 ft./sec.^{2} becomes $3(\text{yards} \div 3/(\text{min.}^2 \div 3600) = 3600$ yards/min.^{2}

or 3,600 *yards per min.* per minute.

Another solution:

3 *feet per sec.* per sec. = 1 *yard per sec.* per sec. = 60 *yards per minute* per sec. = 3,600 *yards per minute* per minute.

16 1-4 ft. was travelled in the *seventh* second.

Distance in t seconds $= 1\text{-}2\ at^2$

In *seven* seconds, $d_7 = 49a/2$

in *six* seconds, $d_6 = 36a/2$

in the *seventh* second $49a/2 - 36a/2 = 13a/2 = 16\ 1\text{-}4 = 65/4$

Solving for a, $a = 5/2 = 2\ 1\text{-}2$ *ft. per sec.* per sec.

353. *From an examination in Dynamics of The Scottish Universities Examination Board.*

(*a*) Make a drawing of a system of three pulleys in which the strings are attached to the weight; and find the relation between the power and the weight.

(*b*) If each of the three pulleys weigh 2 pounds, find the weight raised if the power applied be 16 pounds weight.

From Mr. Philo F. Hammond, University of Wyoming, Laramie, Wyoming:

"I wish to call attention to the fact that the ideal mechanical advantage of the system of pulleys given on page 294 of the March number of SCHOOL SCIENCE is seven and not one. One pound tension on F gives 1, 2, and 4 pounds tension on the ropes attached to W respectively. It the weight is lifted one foot, the upper movable pulley drops one foot, the second movable pulley drops three feet, and the arrow at F must, therefore drop seven feet. . . . Under (*b*) tensions are 16, 34 and 70 respectively. W, therefore, equals 120 pounds neglecting all friction and weight of rope.

This sort of 'hitch' as it is called is used in the logging sections of the West.

With pulleys weighing 36 gms. 50 gms will nearly balance 500—Tensions $50+136+308$ or 494 gms."

NOTE ON THE COMPARATIVE VELOCITIES OF POINTS ON A ROLLING WHEEL.

BY M. H. PEARSON,

Lamier High School, Montgomery, Ala.

The velocity of the bottom point of a wheel rolling on a straight line is zero, and that of the top point is double the velocity of the tip of the hub. This is shown by the following solution which was induced by two men referring a wager to the writer.

A point on the rim of a wheel rolling as stated above generates a cycloid. The parametric equations of a cycloid are

$$x = a\theta - a\sin\theta,$$

$$y = a - a\cos\theta.$$

$$dx/dt = a(1-\cos\theta)d\theta/dt,\ dy/dt = a\sin\theta\ do/dt.$$

Hence, the horizontal velocity of the bottom point is 0, $\theta = 0°$; but the horizontal velocity of the top point is $2a(do/dt)$, $\theta = 180°$.

The velocity of a point along the cycloid is:

$$v = ds/dt = \sqrt{(dx/dt)^2 + (dy/dt)^2} = \sqrt{a^2(1-\cos\theta)^2 + \sin^2\theta)\ (do/dt)^2}$$

or, $v = a\sqrt{2(1-\cos\theta)}\ do/dt$.

Here again for a bottom point, $\theta = 0°$, $v = 0$; and for a top point, $\theta = 180°$, $v = 2a(d\theta/dt)$.

Instead of the angles 0° and 180° we should say even and odd multiples, respectively, of 180°.

Eastern Association of Physics Teachers

The eighty-ninth meeting of this most lively Association will be held at the Coles Laboratory, Newport, R. I., Saturday, May 14, 1921.

Since so many of its members live in and near Boston, provision has been made to take the 8:49 a. m. train from the South Station, arriving at Newport at 11:09. The party will proceed at once to Government Landing, taking the ferry to Torpedo Factory, Goat Island. The return will be made at 12:45 p. m. for luncheon at the Miantonomi Club.

The afternoon session will be held at the Laboratory Building, at the rear of the City Hall and the Townsend Industrial School. First will come general business and report of committees.

Dr. Warren C. Vosburgh will give an address on the Construction and Recent Application of the Constant Potential Cell. This will be followed by an Illustrated Lecture, by Commander Staples, U. S. N., on the Development of the Submarine.

This is a most interesting program and every physics teacher within a radius of 150 miles, who possibly can, should attend the meeting not only for his own sake but for his pupils as well.

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THE GROWTH OF GEOGRAPHY IN AMERICAN UNIVERSITIES.

By W. H. Whitbeck,
University of Wisconsin.

Recently tabulated statistics show that geography is now being taught in thirty representative American universities and in all the enrollment is growing rapidly, in fact so rapidly that it is impossible to provide new instructors for the increasing enrollment each year.

In 1901 there was only one institution in the country that enrolled more than one hundred students in geography, that was Chicago with 150 students. The department of geography today is one of the largest at Chicago. The University of Wisconsin which enrolled about eighty students in 1901 now enrolls more than a thousand each semester and the University of Pennsylvania showing the largest enrollment in geography in the country usually has more than 1,100 each semester. Chicago, Wisconsin and Pennsylvania each has eight or more on its teaching staff who teach geography only, while many other institutions have a staff of five each. All these institutions equipped with graduate schools are offering graduate courses leading to the higher degrees.

In the earlier years physical geography and meteorology were the two phases of the subject which were most widely taught. In recent years, however, the drift has been strongly toward the human and applied phases of the subject. These courses include regional studies, such as the Geography of North America and of the other continents and courses in both the elementary and advanced phases of industrial and commercial geography. A dozen or more institutions offer courses which emphasize the inter-relation between man and his geographical environment. This is the key-note of modern scientific geography. It is generally recognized that the lifting of geography to the position of a distinct science will be attained by the pursuit of studies in the field of geographic influence and human response.

European universities have gone further in the development of geographical courses than have most American institutions. Every one of the twenty-six universities of Germany has one or more chairs of Geography. The University of Paris has a faculty of nearly a dozen men in the various phases of geography. Oxford, England, has a School of Geography which is recognized as the leader in the British Isles. Practically all the English and Scotch Universities give courses in geography and accept these courses as partial fulfillment of requirements for their highest degrees. Most Italian, Austrian, Hungarian, and Russian universities have departments of geography; many of thee are well equipped and highly developed. In short, geography is nows firmly established throughout the civilized world as a branch of higher education. In European universities it is most commonly associated with history. In American universities it is most often associated with the Department of Geology. In fact the leaders of thought in America, so far as geography is concerned, have generally been trained as geologists. The present drift, however, is strongly toward the human side of the subject and more and more men who are interested in anthropology, history, economics, and sociology are recognizing the services of scientific geography, because of its value in their fields of study. There is no doubt that this development of geography will continue in American universities and that the courses offered will become more and more matured and scholarly.

For purposes of general culture, geography ranks with history. Just as educated people are supposed to know the outlines of the history of the great nations of the past and present, so they will be supposed to

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know the geography of the nations which make up the modern world. It takes time for a new idea to gain a hearing, and we have been in the habit of considering that the study of the history of Greece, Egypt, Babylonia, the mediaeval nations, modern England, Germany, and France are integral parts of a liberal education. Just as truly we shall recognize that the study of geography of modern Germany, France, Russia, China, Japan, Argentina, and Brazil are integral parts of a liberal education. When our thinking has adjusted itself to these new ideas, college faculties will admit that geographical studies are scarcely less valuable than historical studies, provided they are developed in a mature and scholarly way.

The great war emphasized the value to educated people of a knowledge of the nations of the world, a knowledge of the resources of Russia, of Germany, of Japan, and of our own country; their food-producing capacity, their supplies of coal and iron, and their ability to manufacture the things most needed in war and in peace. Modern geography involves also a study of their political and social institutions, their industrial stage, their power of organization and initiative, the strength or weakness of their governments, the efficiency of their transportation facilities, the character of their sea coast, their military, naval and financial strength, their progress in education and science, and the inventive genius of their people. It is going to be recognized that an understanding of the great nations of today is as full of interest and value as a knowledge of the history of the nations of antiquity. It seems no violence to the facts, as presented by the events of the last decade, to predict that the next decade will find geography a thoroughly respected and esteemed branch of education in all American universities.

HAS AMERICA NO ANSWER FOR THIS GERMAN THREAT?

While men talk about disarmament and fill the newspaper columns with learned discussions as to the wisdom of curtailing our naval program by international agreement, hour by hour the day of our real disarmament approaches, and approaches so stealthily that the great public is in entire ignorance of the fact.

In the next war leaders will laugh at battleships and artillery when they launch their assaults of poison gas and invisible destruction. The machinery of warfare has passed into the hands of chemists and the soothsayers in predicting results, will look not to stars or entrails, but into the test tubes of the laboratory.

An inkling of the truth may be obtained from a cable dispatch written by Wythe Williams, which appeared in the Washington Herald of January 10. We quote from it:

"There is evidence in Paris, where a large force of dye experts now are gathered to help the reparations commission, that the German dye attack is to be centered most vigorously upon the United States market. France has a tariff law that enables her to build up her dye industry unmolested. England has a new law, operative January 15, that excludes dyes such as she produces and admits those she does not produce, but which her consumers need. Japan is taking steps to protect her chemical industry. The United States is the only important nation actually at the mercy of the German chemists. For the moment America is protected by the War Trade Board, but this barrier will fall when she ends the technical state of war with Germany.

"Germany dye manufacturers, realizing this, are causing the reparations commission much trouble by refusing to produce, except under

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pressure, the dyes most needed in the United States. They are willing to offer large quantities of dyes in competition with the output of the new American dye industry, but still are making excuses for failure to produce noncompetitive dyes. Thus they hope to encourage consumers to demand an open market. Also, in this manner, with the experience of her fifty years' world monopoly of dye manufacture against five years of American experience, Germany hopes to throttle the American industry and leave America helpless in this respect should there be another war.

"German production of dyes is so closely allied with her production of munitions that a separation is impossible. Destruction of one would meal the destruction of both. Students of the German proposals now in Paris consider that America is the last hope the German manufacturers have, and they will not give up as long as America does not protect its dye industry by a law similar to that of Great Britain. They see, further, that real chemical disarmament can be accomplished only by breaking Germany's monopoly of the dye industry and encouraging the building up of a similar industry in all the countries of the entente, and especially in the United States."

It is the absolute truth that the "United States is the only important nation actually at the mercy of the German chemists."

The War Trade Board, which now protects the American dye industry, will go out of existence March 4 unless funds to finance its activities are provided, and it will go out of existence anyhow so soon as peace is concluded. The dye industry, therefore, is nearing hour by hour the day when it will be at the mercy of the Germans. That will not be long. Private industry does not possess the power of taxation and cannot long stand up under heavy financial losses. If there is no inhibitory legislation, enough dyes can be dumped on our shores within a few months to swamp the market.

It is difficult to speak with moderation of those Senators who have resorted to the filibuster and every other technical device of legislators to delay and prevent enactment of the dye bill. Be their motives what they may, the fact remains that their course is exactly the course that is most acceptable to the Germans. There is no one thing Berlin more desires than the failure of the Longworth Bill. Men who shape their course in Congress so as to support a policy obviously beneficial to our enemies and destructive to the United States necessarily are objects of suspicion. Men are judged not by their motives, but by the things they do, and when the things they do are fatal to the future well-being of their country, they must expect criticism. This is more than ever true when they obstruct the majority and employ their technical power of delay to prevent an enactment favored not only by the House of Representatives and recommended by the President, but also favored by a large majority in the Senate itself.

There is history back of this entire situation. The statesmen who went to Paris to write the Peace Treaty were well aware that a mere physical disarmament of Germany would be a grotesque provision against the later attack by that nation. They favored not merely the destruction of the German navy and the disbandment of the German army, but they also expected to compel the Germans to disclose their chemical secrets, vital in warfare, and the dismantlement of huge chemical works was contemplated. This essential and wise course was prevented by President Wilson, who advanced the idea that the Allies and the United States could adequately protect themselves by building up their own chemical industries, shutting out the German product. He favored compelling

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the Germans to disclose their chemical secrets, which they have not done, but he wanted each individual nation to protect itself.

That is what all of the chief Allies and neutral nations have done—all except the United States. Over in England the Government listened to all the arguments against protection of the British dye industry and then promptly enacted, recently, the most drastic sort of legislation to assure absolutely that the German chemical industry would not ruin that of Great Britain. She carried out the understanding that had been reached in Paris. It is more than passing strange, however, that every effort to carry out the same understanding in the United States has been prevented by filibusters or threats of filibusters in the Senate. It is amazing, but it is true.

It is a fact that the Germans have not yet yielded up their war method of extracting nitrogen from the air. The methods we have are obsolete, and we know it. But we have not the final Haber process. It will be got, in one way or another, but it has not yet been obtained.

If gentlemen wish to continue the argument on the dye bill, let them do so, but not with the gates open. The barriers must at least be kept up until a definite decision has been reached. This can be done by passage of a joint resolution extending the authority of the War Trade Board and providing funds wherewith to support it. The Longworth Bill itself ought to be passed. It is the sensible and proper course. But, failing that, the next best course is emergency protection of the chemical industry pending a final decision by the next Congress on a definite national policy.

The absolutely essential character of the dye industry in relation to national defense is not a question of conjecture or of theory. It has been demonstrated with mathematical accuracy, and it can be so demonstrated at any time, before any committee or any jury. Indeed, it is admitted even by the opponents of the Longworth Bill. They claim, however, that the industry can be protected adequately by tariffs. The facts are all against them. Tariffs are for honest men, in pure commerce. Control of the American dye market by the Germans is not inherently a commercial undertaking at all. Germany can afford to give away dyes in America if by so doing she can destroy the American dye industry. Dyes, with her, is preparedness for war. Dyes, with us, can be nothing else.

We would be safer without a gun factory in the nation, a powder plant or a warship than without a chemical industry and a chemical personnel equal to any others on earth.—[*Manufacturers Record.*

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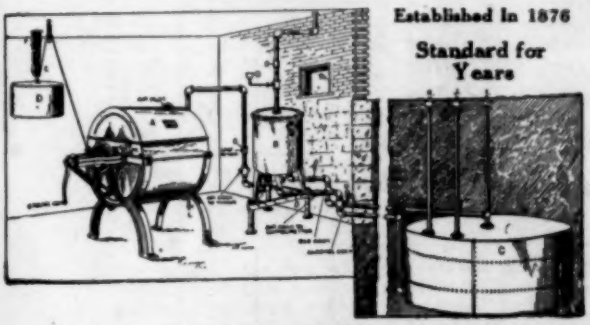

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3. Micrometer caliper	2	0	0	1	9
4. Laws of liquid pressure	0	15	2	13	1
5. Hooke's Law	10	2	1	1	3
6. Archimedes Principle	3	1	9	0	11
7. Specific gravity of metals	2	2	4	2	4
8. Specific gravity of paraffin	0	2	0	0	0
9. Lung pressure	5	2	4	0	1
10. Boyles' Law	0	2	2	3	1
11. Concurring forces	0	1	3	7	2
12. Parallel forces	8	0	7	3	1
13. Law of pendulum $t:t::\sqrt{l}:\sqrt{l}$	1	21	6	8	5
14. Wt. of lever at center of gravity	0	1	2	1	3
15. Law of moments	1	4	0	4	3
16. Inclined plane	9	0	11	1	1
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BOOKS RECEIVED

Elementary Calculus, by William F. Osgood, Harvard University. Pages ix+224. 13×19 cm. Cloth. 1921. The Macmillan Company, New York City.

An Outline of Physics by L. Southenu. Pages xv+202. 13×19 cm. Cloth. 1921. $2.50 net. E. P. Dutton Company, 681 Fifth Ave., New York City.

Elementary Electrical Engineering, by Ralph P. Clarkson. Acadia University, Wolfville, N. S. Pages xvi+187. 14×19 cm. Cloth. 1920. $2.00 net. D. Van Nostrand Company, New York City.

Plane Geometry, by Herbert E. Howkes, Columbia University, William A. Luby, Junior College, Kansas City and Frank C. Tooten, Supervisor of High Schools, Madison, Wis. Pages vii+305. 13.5×19 cm. Cloth. 1920. $1.32. Ginn and Company, Chicago, Ill.

The Elements of Plane Geometry, by Charles Davidson, formerly of King Edward's High School, Birmingham. 284 pages. 13×19 cm. Cloth. 1920. University Press, Cambridge, England.

The Fundamentals of Argumentation and Debate, by J. Walter Reeves, Peddie Institute, Hightstown, N. J. Pages vi+82. 11.5×17 cm. Cloth. 1920. D. C. Heath and Co., Boston, Mass.

Factory Chemistry, by Wm. H. Howkes, Ford Institute, Detroit, Mich., pages vii+59, 12.5×19 cm. Cloth. 1921. $1.00 net. Longman's, Green & Co., New York City.

Catechismo Civile Dei Diritti E. Doveri Dei Cittadnii Americani, English-Italian. 94 pages. 13×19 cm. Paper. 1920. National Catholic Welfare Council. 1312 Massachusetts Ave., N. W., Washington, D. C.

Illinois Arbor and Bird Days, Circular No. 151; directed by Francis G. Blair, Superintendent of Public Instruction. 68 pages. 59 half-tones and cuts. 15×23 cm. Paper. 1921. Superintendent of Public Instruction, Springfield, Ill.

Die Starie Von Herman Hahn Die Schroubenfeder Von Curt Fifches. 186 pages. 17×26 cm. Paper. 1920. Verlog von Quelle and Meyer in Leipzig.

Parallaxes of 260 Stars, Y. S. A. Mitchell, University of Virginia. Pages v+694. 24×32 cm. Paper. 1920. Columbia University Press, New York City.

A history of Public-School Support in Minnesota, 1858 to 1917 by Frances E. Kelley. Pages IX—103, 15x22.5 cm. paper, 1920. 75 cents. University of Minnesota, Minneapolis.

BOOK REVIEWS.

The American Red Cross in the Great War, by Henry P. Davison, Chairman. 302 pages. 13 x 19.5 cm. Cloth. 1920. The MacMillan Co., New York City.

People who are not very familiar with the operations of the American Red Cross in the recent great war should read this most excellent book. It gives one a pretty good idea of the ramifications of the work that this association did. There are no specific stories of privation, or sacrifice given, yet, the work of this great army of Red Cross workers is summarized in this book. "The Red Cross is not the work of any single individual or group of individuals, but it is accomplished by the united effort of millions of people.

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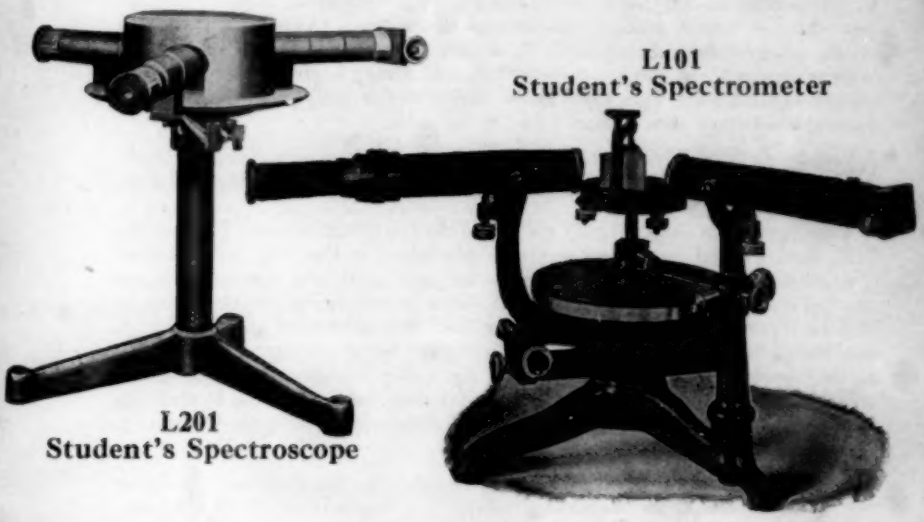

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the amount of money raised and how it was spent. Also, there is a splendid index. It is well written and well worth the while for every American citizen to read. C. H. S.

Introduction to General Chemistry, by H. Copaux, Professor of Mineral Chemistry at the School of Industrial Physics and Chemistry of the City of Paris. Translated by Henry Leffmann, A. M., M. D., 1920. 12.5 x 18.4 cm., with 30 illustrations. Cloth. 1920. Pages x +195 P. Blakiston's Son & Co., Phila.

This is a very fine little synopsis of the principles of chemistry. The student who really studies it should have no excuse for saying as the author states in his preface that Van't Hoff once asserted at a conference, that he had not understood Avogadro's postulate until it became his duty to teach it. Not only is the hypothesis of Avogadro clearly presented but the other fundamental laws and the principal theories of general chemistry are equally well handled. A list of the chapter headings may be helpful as showing the content and order of presentation of the book. I. The Idea of the Element—The Law of Conservation of Matter. II. Laws of Chemical Combination. III. Atomic Theory; Chemical Formulas. IV. General Characters and Inter-relations of the Elements. V. Properties and Theory of Solutions. VI. Chemical Affinity. This last chapter has a section on thermo chemistry. Appendix A treats briefly of crystals and Appendix B, which was contributed by the translator treats of hydrogen ion concentration. Every high school chemistry library should have this little book and many a college student in the general chemistry course would find it valuable. F. B. W.

Efficiency Drills in Arithmetic, by G. M. Lisk, Northwestern State Teachers' College, and A. W. Fanning, Superintendent of City Schools, Alva, Oklahoma.

This set of ten cards, 6 x 21 cm., enables the grade teacher to give the drill work needed to make her pupils proficient in the four fundamental operations. There are fifty problems on each card, and the answers are printed on the back. Care has been taken in arranging the problems so that no two consecutive operations are so closely connected that the pupils can memorize the answers. Test sheets are being prepared for the use of the superintendent whose teachers are using the cards. These sheets will enable him readily to determine what progress each room is making. These cards may be obtained of The Efficiency Publishing Company, Alva, Oklahoma, at $2.50 a hundred. H. E. C.

Elementary Calculus, by William F. Osgood, Ph. D., Perkins, Professor of Mathematics in Harvard University. Pages ix+224, 13 x 19 cm. 1921. The MacMillan Company, New York.

This book presents the elements of differential calculus in a form easily accessible for the undergraduate. From the very beginning the ideas and methods of calculus are illustrated by means of applications to physics and geometry, which are readily understood by the student and which will seem to him of interest and value. In addition to this the necessary training in the formal processes and technique of calculus are provided. An important subject which has received little attention by writers of textbooks in calculus is given in Chapter VII. Here the common methods in use by physicists and others who apply calculus in solving approximately numerical equations which do not come under the standard rules of algebra and trigonometry are set forth and illustrated by simple examples. Several other interesting departures from the conventional treatment of calculus are noted, which make this a most excellent textbook. H. E. C.